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AN INSTRUMENTAL ANALYSIS WAS UNDERTAKEN, AND A DETAILED DESCRIPTION PREPARED OF THE PHONETIC FEATURES OF AMERICAN ENGLISH AND THE COMMONLY TAUGHT MODERN FOREIGN LANGUAGES, GERMAN, SPANISH, AND FRENCH. THE INVESTIGATION COVERED 40 SECTIONS (1) 11 PROSODIC FEATURES, (2) 13 VOCALIC FEATURES, AND (3) 16 CONSONANT FEATURES. A THREE-WAY TECHNIQUE WAS USED--(1) THE SPECTROGRAPHIC ANALYSIS OF UTTERANCES THAT WERE COMPOSED AND RECORDED FOR SPECIAL PURPOSES, (2) THE VERIFICATION AND REFUTATION OF SPECIFIC HYPOTHESES BY MEANS OF SPECTOGRAPHIC SYNTHESIS UPON WHICH SPECTOGRAPHIC PATTERNS OF CONTRASTIVE UTTERANCES WERE PAINTED AND TRANSFERRED INTO SOUND BY A SPEECH SYNTHESIZER, AND (3) THE PREPARATION AND STUDY OF MOTION PICTURES 'X-RAYS' OF THE UTTERANCES TO DISCOVER ARTICULATORY FEATURES THAT CORRELATE WITH THE ACOUSTIC ONES FOUND BY SPECTROGRAPHIC ANALYSIS AND SYNTHESIS. ENGLISH AND THE FOREIGN LANGUAGES WERE COMPARED USING STATISTICAL ANALYSIS. (HB)

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THE GENERAL PHONETIC CHARACTERISTICS OF LANGUAGES, FINAL REPORT

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THE PROBLEM

In the teaching of foreign languages to American students one of the major problems has always been that of acquiring a satisfactory pronunciation. Language Institutes have had more difficulty in this respect than in any other. With the present emphasis on "speaking," this problem has taken on more importance every year. In order to make an effective use of the phonemic system of a second language, one must develop good articulatory habits. Improvements in the teaching of pronunciation have been hampered by an insufficient knowledge of the segmental and prosodic features of foreign languages. Problems of interference are partly due to a lack of really objective data on the phonetic features of the first language as well as of the second -- data which would allow phonetic contrasting of the two languages in a truthful and realistic manner.

OBJECTIVES

The long range objectives of this project are the instrumental analysis and detailed description of the phonetic features of American English and of the foreign languages that are commonly taught in the United States. The foreign languages toward which our main attention is turned at present are German, Spanish, and French. Results of our investigations are to appear in article or book form.

Exploratory research has led us to divide our investigation into 40 sections -- 11 prosodic features, 13 vocalic features, and 16 consonant features. As a result, we are comparing English to German, English to Spanish, English to French, each under the 40 following headings:

Prosodic Features: 1. Declarative Intonation. 2. Non-Declarative Intonation. 3. Place of Logical Stress in the Word. 4. Place of Logical Stress in the Sense Group. 5. Nature of Logical Stress. 6. Place of Emphatic Stress. 7. Nature of Emphatic Stress. 8. Variations in Syllable Weight. 9. Internal Juncture and Syllabication. 10. Syllable Type. 11. Tension.

Vocalic Features: 12. Articulatory Description. 13. Acoustic Description. 14. New Vowel Sounds for the English Speaker. 15. Distribution (Positional and Allophonic). 16. Frequency of Occurrence. 17. Duration System. 18. Neutral Position. 19. Loss of Color. 20. Effect of Consonant Anticipation on Vowels. 21. Diphthongization. 22. Effect of Syllable Type on Vowel Color. 23. Attack and Release. 24. Nasality.

Consonantal Features: 25. Articulatory Description. 26, Acoustic Description. 27. New Consonant Sounds for the English Speaker. 28. Distribution (Positional and Allophonic). 29. Frequency of Occurrence. 30. Duration System. 31. Neutral Position. 32. Consonantal Weakening. 33. Effect of Vowel Anticipation on Consonants. 34. Speed of Articulation. 35. Tongue Fronting. 36. Aspiration. 37. Affrication. 38. Palatalization. 39. Final Release. 40. Voicing.

PROCEDURES

In order to complete these investigations with a high degree of objectivity, we have developed a three-way instrumental technique of research based on the successful design and construction of special instrumentation.

1) This three-way technique generally begins with the spectrographic analysis of utterances that have been composed and recorded for a special purpose. The comparison of spectrograms of English with corresponding ones of German, Spanish or French leads to making some hypotheses as to the acoustic differences between English and the other languages, regarding certain phonetic characteristics.

2) Then, the hypotheses are verified or refuted by means of spectrographic synthesis. Spectrographic patterns of the contrastive utterances are painted and transferred into sound by a speech synthesizer. It is thus possible to judge by ear to what extent the assumed acoustic differences produce the appropriate auditory differences.

3) Finally, motion picture X-rays of the utterances are made and studied frame by frame by means of special projectors, to discover the articulatory features that correlate with the acoustic ones found by spectrographic analysis and synthesis.

4) As a complement to this instrumental research, phonetic features of English and foreign languages are investigated by statistical analysis, related to such features as phoneme frequency, phoneme distribution, syllable types, etc.

RELATED RESEARCH

Our investigation of the phonetic characteristics of languages is related to research in the general field of Applied Linguistics in that it will contribute to our contrastive knowledge of English and foreign languages and will make it possible to improve their teaching.

It is also related to research in Methodology, seeing that experiments aimed at obtaining better results in language teaching will use our data.

Finally, it is related to research in General Linguistics because our acoustic and articulatory studies are closely connected with the determination of the "distinctive features" of phonemes and prosodemes.

RESULTS

During this year of research under contract with the Office of Education we have completed five studies, the texts of which follow.

THE TEN BASIC INTONATIONS OF FRENCH

I. INTRODUCTION

In a language like French, there is more than one way to transform a statement such as Vous sortez into a question. It can be done in writing by changing the punctuation Vous sortez. to Vous sortez?, and orally by inverting the word order: Sortez-vous, or by the use of an interrogative marker: Est-ce que vous sortez? But it can also be done by exclusively changing the intonation of the phrase from

```
                                            z
                                          e
Vous                                    t
          sor                       sor
                   to          vous
     tez
```

THE TEN BASIC INTONATIONS OF FRENCH

This last method will be the object of our study; we will examine the significant functions of intonation in relation to its ascending and descending shapes.

Intonation is not without some linguistic function comparable to that of phonemes, morphemes and tagmemes; in any case, analogy is not excluded. Just as the existence and proper function of a segmental phoneme (vowel or consonant) rests upon the meaningful contrasts it authorizes, as well as upon the phonetic features that distinguish it from other phonemes, so the linguistic value of an intonation curve depends on the meaningful contrasts it permits, as well as on the degree of phonetic difference that distinguishes it from other curves. We must analyze, then, both the meaningful contrasts which reside in intonation and the shape of the intonation curves that relate to those contrasts.

Intonation is one of the prosodic features of language. These features are also known as suprasegmentals since they do not apply separately to "segments,"

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z
t é
Vous sor
sor to
Vous
tez

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Intonation is one of the prosodic features of language. These features are also known as suprasegmentals since they do not apply separately to "segments," vowels and consonants, but to words and sense groups. Other prosodic features are stress, rhythm, syllabication, and pause.

All of these terms are subjective. One must therefore understand the term "intonation" as a subjective notion that permits us to distinguish one form of logical expression from another (question, command, continuation, finality, etc.) or a mere emotional attitude from another (surprise, curiosity, impatience, fear, joy, etc.). What we perceive subjectively as a certain intonation is objectively the result of variations in a number of acoustic features -- irreducible factors of voice: intensity, duration and frequency. However, since this last feature -- variations in the fundamental frequency of the speaking voice -- plays the principal role in the perception of intonation, we will concern ourselves primarily with this "fundamental." To limit ourselves still further, we will only examine the variations of this fundamental in relation to basic patterns of logical expression, such as questions and commands, without trying to penetrate into the labyrinth of emotive attitudes such as surprise and joy.

II. EXPERIMENTAL PROCEDURE

The objective form of intonation curves and their subjective interpretation have been studied with the aid of special instruments which will be mentioned very briefly.

1. Spectrograms of speech samples to be studied make it possible for one to visually follow variations of the fundamental frequency, along with variations in duration and intensity.[1]

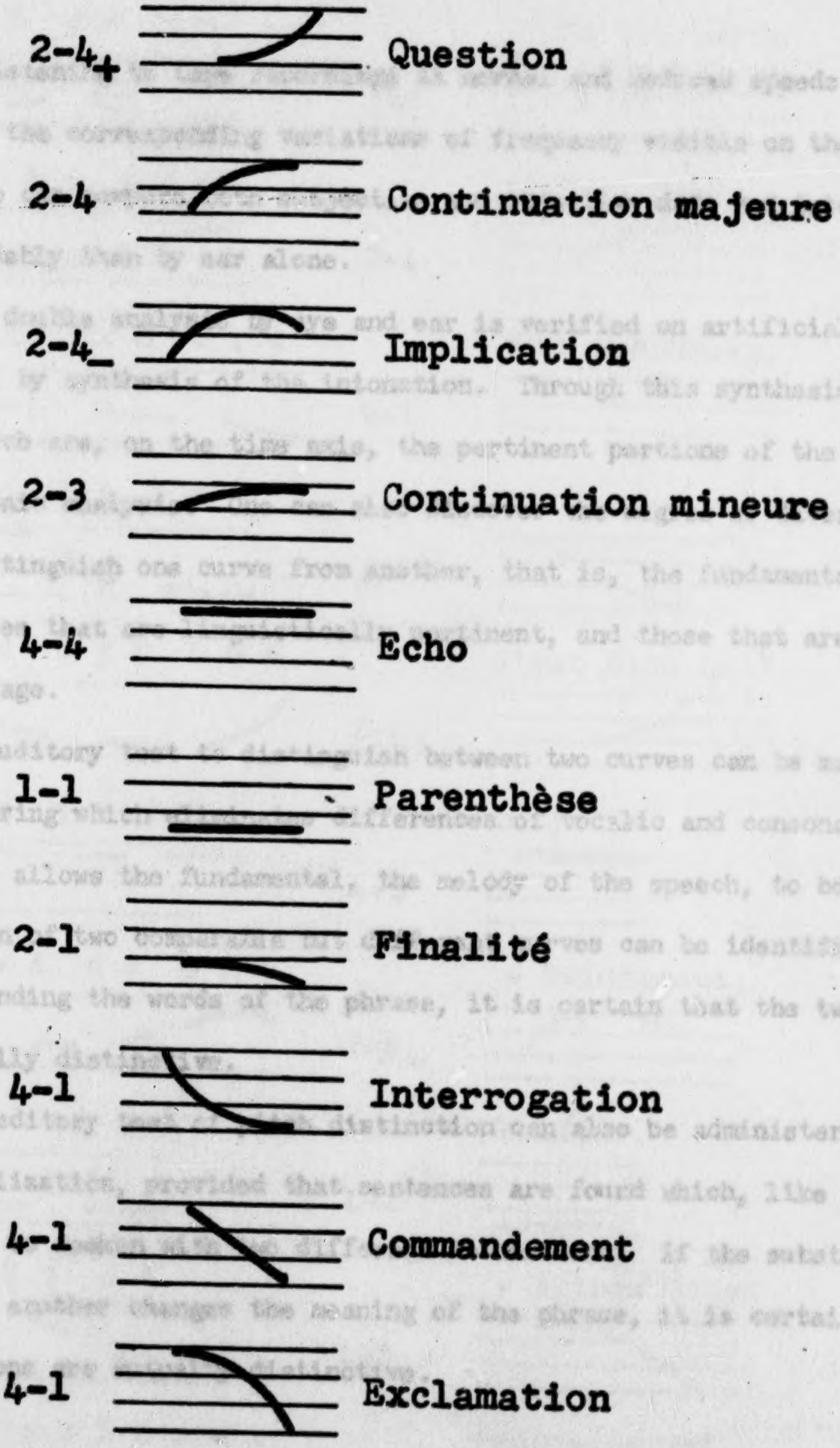
2-4+
Question
2-4
Continuation majeure
2-4_
Implication
2-3
Continuation mineure
4-4
Echo
1-1
Parenthèse
2-1
Finalité
4-1
Interrogation
4-1
Commandement
4-1
Exclamation

Figure 1

2. By listening to tape recordings at normal and reduced speeds, while following the corresponding variations of frequency visible on the spectrogram, one can compare both subjective and objective data and interpret them more dependably than by ear alone.

3. This double analysis by eye and ear is verified on artificial speech machines, by synthesis of the intonation. Through this synthesis, one can discover which are, on the time axis, the pertinent portions of the curves shown by electronic analysis. One can also discover the degree of divergence necessary to distinguish one curve from another, that is, the fundamental frequency differences that are linguistically pertinent, and those that are not, in a given language.

4. The auditory test to distinguish between two curves can be made by electronic filtering which eliminates differences of vocalic and consonantal timbre, and only allows the fundamental, the melody of the speech, to be heard. If the intonation of two comparable but different curves can be identified without understanding the words of the phrase, it is certain that the two curves are mutually distinctive.

5. The auditory test of pitch distinction can also be administered by semantic neutralization, provided that sentences are found which, like those in Figure 3, can be spoken with two different intonations. If the substitution of one curve for another changes the meaning of the phrase, it is certain that the two intonations are mutually distinctive.

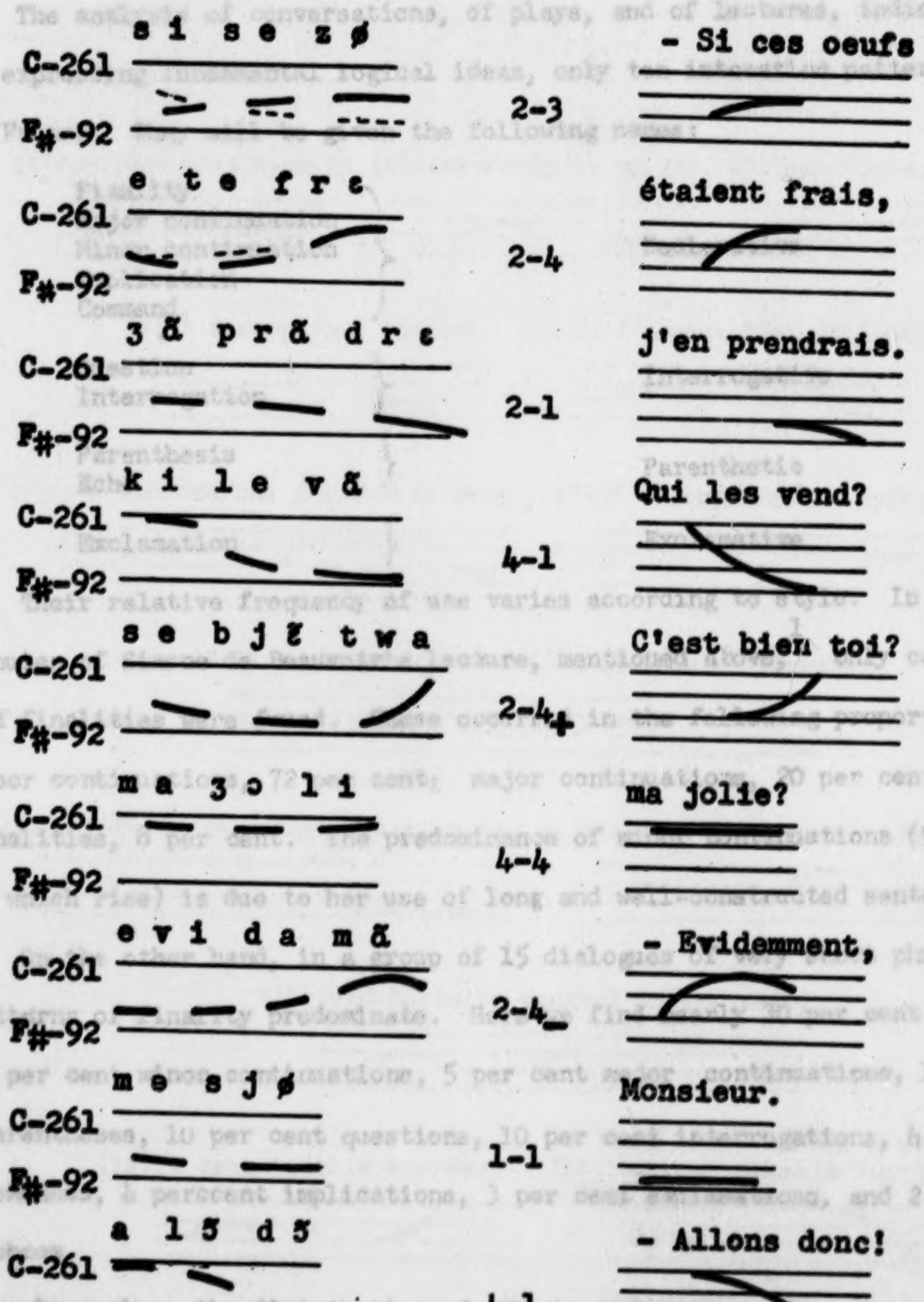
s i s e z ø
C-261
F#-92
2-3
- Si ces oeufs
e t e f r ɛ
C-261
F#-92
2-4
étaient frais,
ʒ ɑ̃ p r ɑ̃ d r ɛ
C-261
F#-92
2-1
j'en prendrais.
k i l e v ɑ̃
C-261
F#-92
4-1
Qui les vend?
s e b j ɛ̃ t w a
C-261
F#-92
2-4+
C'est bien toi?
m a ʒ ɔ l i
C-261
F#-92
4-4
ma jolie?
e v i d a m ɑ̃
C-261
F#-92
2-4−
- Evidemment,
m e s j ø
C-261
F#-92
1-1
Monsieur.
a l ɔ̃ d ɔ̃
C-261
F#-92
4-1
- Allons donc!
p r u v l ə m w a
C-261
F#-92
4-1
Prouve-le-moi.

Figure 2

III. SOME STATISTICS

The analysis of conversations, of plays, and of lectures, indicates that in expressing fundamental logical ideas, only ten intonation patterns are used in French. They will be given the following names:

Finality Major continuation Minor continuation Implication Command	Declarative
Question Interrogation	Interrogative
Parenthesis Echo	Parenthetic
Exclamation	Exclamative

Their relative frequency of use varies according to style. In the five minutes of Simone de Beauvoir's lecture, mentioned above,[1] only continuations and finalities were found. These occurred in the following proportions: minor continuations, 72 per cent; major continuations, 20 per cent; finalities, 8 per cent. The predominance of minor continuations (92 per cent of which rise) is due to her use of long and well-constructed sentences.

On the other hand, in a group of 15 dialogues of very short phrases, patterns of finality predominate. Here we find nearly 30 per cent finalities, 21 per cent minor continuations, 5 per cent major continuations, 11 per cent parentheses, 10 per cent questions, 10 per cent interrogations, 4 per cent commands, 4 perccent implications, 3 per cent exclamations, and 2 per cent echoes.

In a play, the distribution of the ten intonations seems to be between these two poles. A reading of Huis Clos gave the following proportions: minor continuation, 25 per cent; major continuation, 7 per cent; finality,

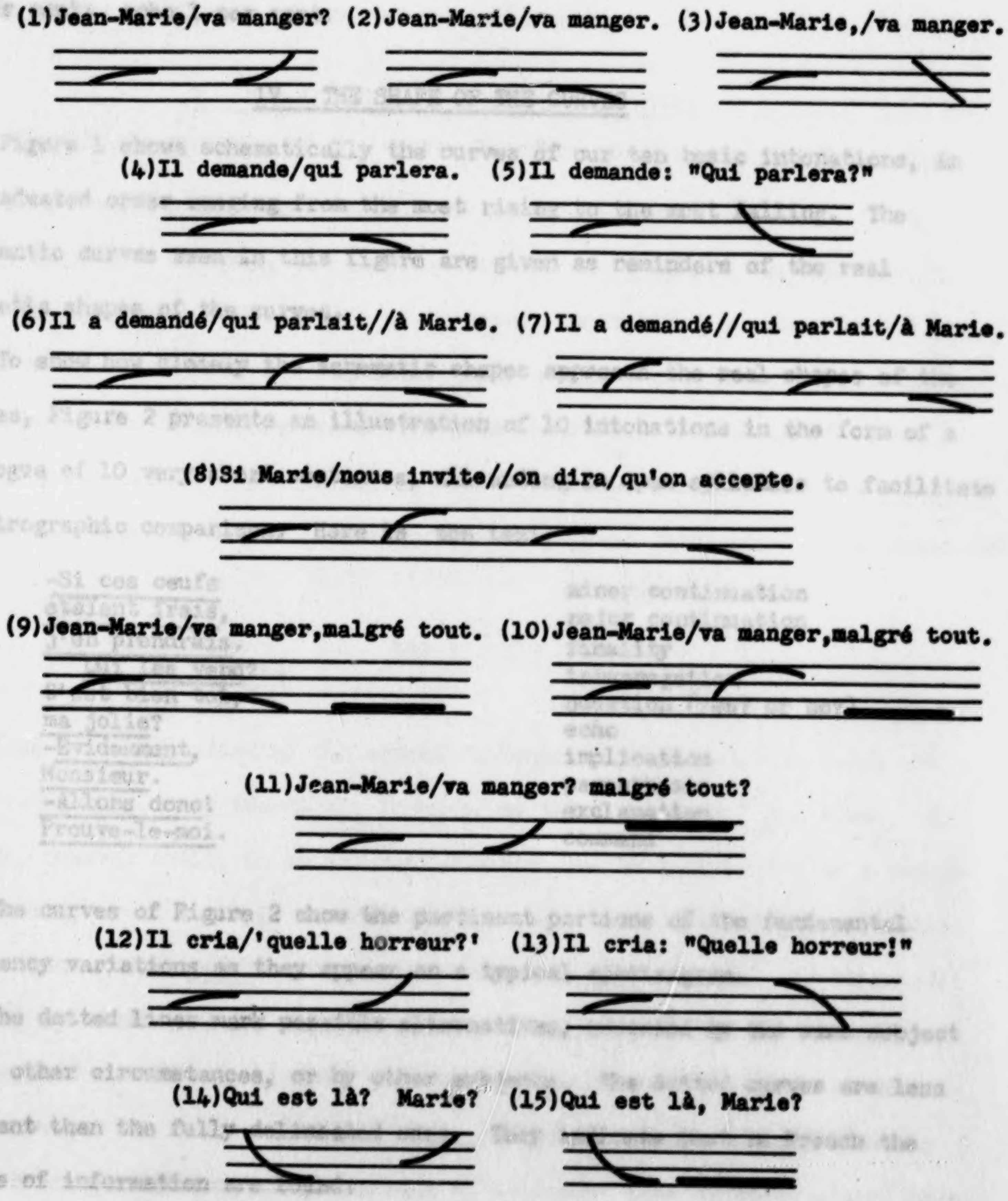
(1)Jean-Marie/va manger?
(2)Jean-Marie/va manger.
(3)Jean-Marie,/va manger.
(4)Il demande/qui parlera.
(5)Il demande: "Qui parlera?"
(6)Il a demandé/qui parlait//à Marie.
(7)Il a demandé//qui parlait/à Marie.
(8)Si Marie/nous invite//on dira/qu'on accepte.
(9)Jean-Marie/va manger,malgré tout.
(10)Jean-Marie/va manger,malgré tout.
(11)Jean-Marie/va manger? malgré tout?
(12)Il cria/'quelle horreur?'
(13)Il cria: "Quelle horreur!"
(14)Qui est là? Marie?
(15)Qui est là, Marie?

Figure 3

32 per cent; question, 7 per cent; interrogation, 5 per cent; command, 7 per cent; implication, 5 per cent; exclamation, 8 per cent; parenthesis, 3 per cent; echo,1 per cent.

IV. THE SHAPE OF THE CURVES

Figure 1 shows schematically the curves of our ten basic intonations, in a graduated order ranging from the most rising to the most falling. The schematic curves seen in this figure are given as reminders of the real phonetic shapes of the curves.

To show how closely the schematic shapes approach the real shapes of the curves, Figure 2 presents an illustration of 10 intonations in the form of a dialogue of 10 very short sentences, all ending in open syllables to facilitate spectrographic comparison. Here is the text:

-Si ces oeufs	minor continuation
étaient frais,	major continuation
j'en prendrais.	finality
Qui les vend?	interrogation
C'est bien toi,	question (yes? or no?)
ma jolie?	echo
-Evidemment,	implication
Monsieur.	parenthesis
-Allons donc!	exclamation
Prouve-le-moi.	command

The curves of Figure 2 show the pertinent portions of the fundamental frequency variations as they appear on a typical spectrogram.

The dotted lines mark possible alternatives, recorded by the same subject under other circumstances, or by other subjects. The dotted curves are less frequent than the fully delineated ones. They indicate that in French the points of information are found:

(a) in the rising intonations which aim at level 4, on the last syllable of a sense group; and (b) in the descending intonations which begin at level 4, on the first and last syllables of the sense group.

V. THE SIGNIFICANT FUNCTION OF CURVES

The phonetic analysis of the curves found on spectrograms furnishes the characteristic shapes used as models in teaching French intonation. This analysis is not, however, the only factor used to determine the four levels shown in the graphs. The points of reference represented by these levels are based on oppositions of meaning achieved by prosodic substitution, similar to the oppositions of meaning which come from phonemic substitution of sound segments and produce "minimal pairs." Thus the opposition of meaning boue/but by the substitution of the second phoneme /bu/by/ is comparable to the opposition:

mi
Son a l'a
qui
tté

é
mi t
Son a l'a qui

obtained by substitution of the second "intoneme": /2-3, 2-1/2-3, 2-4/. We say "comparable," not identical, because, as André Martinet 2 has shown, any change, however small, in an intonation curve, can be interpreted as a change of meaning, or as a simple nuance, whereas small variations in the pronunciation of the /u/ of boue do not change the meaning of the word. In linguistic jargon, phonemes like /u/ and /y/ would be called "discrete" units, well categorized and clearly limited in number. As much cannot be said of intonation curves. The question is not, then, to establish the number of levels which French intonation would comprise if intonemes were discrete units, like segmental phonemes, but simply to mark practical reference points to facilitate the schematic representation of basic intonations. It is moreover probable, as Dwight Bolinger believes,[3] that no reference scale can faithfully represent all the intonations of a language.

Figure 3 presents a series of meaningful contrasts based exclusively on the substitution of one intonation curve for another. The sentences compared always have, in fact, the same phonic content of segmental sounds. These contrasts should allow us to judge the potential linguistic value[4] of each of the ten curves whose shape we already know. They should moreover indicate which levels and terminals would most practically represent them schematically. As we are limiting ourselves to 10 basic intonations, our task is simplified.

QUESTION, FINALITY, AND COMMAND

Let us refer back to intonation structures 1 and 2 in Figure 3. The mere substitution of the second curve transforms a question into a statement. Taking provisionally as a base the limited rise of minor continuation 2-3, we see that in order to identify va manger as a question, the curve must rise above 3; hence, we can say that it rises to 4. If, instead of rising, the curve falls, it is understood as finality. But what is the starting-point from which this finality falls? To find out, let us oppose structures 2 and 3 in Figure 3. If the starting-point for the fall of va manger is higher than level 3, a command is understood. In order to avoid all ambiguity with command, finality must have its starting-point below three, hence at 2. And as it falls, it goes from 2 to 1.

We now have our four levels marked. One could dispense with level 1 by calling finality 3-2. This would be more economical, but less clear and practical; moreover, it would not correspond to phonetic reality -- spectrograms regularly indicate finality as starting from a lower frequency than the preceding continuation. This is one of the characteristics of French that must be stressed in teaching.

INTERROGATION

Let us compare intonation structures 4 and 5 (Figure 3), which oppose the indirect discourse, *Il demande qui parlera*, to the direct discourse, *Il demande, "Qui parlera?"* *Qui parlera* becomes an interrogation when it begins higher than peak 3 of the minor continuation, hence at level 4. (The fall of command and interrogation to level 1 is not based on oppositions but is indicated by phonetic analysis of spectrograms, where it generally ends as low as finality 2-1.)

MAJOR AND MINOR CONTINUATIONS

Let us compare intonation structures 6 and 7 (Figure 3). In complete sentences, the two continuations, which we call major continuation and minor continuation, cannot be opposed as a minimal pair of *direct* substitution, but as a minimal pair of *crossed* substitution, as seen in structures 6 and 7. In structure 6, as the highest rise to level 4 is on *qui parlait*, the sentence means: "He asked Mary (to tell him) who was speaking." This meaning, and the intonational sequence that it involves, can be suggested by placing a double bar after *parlait*: *Il a demandé/ qui parlait//à Marie*. In structure 7, *Il a demandé// qui parlait/ à Marie*, by placing the highest rise, 2-4, on *Il a demandé*, the meaning of the whole sentence is modified to: "He asked who was speaking to Mary."

The change of meaning which results from this crossing of different intonation levels of structures 6 and 7 (Figure 3) shows clearly that, in French, the opposition of levels 3 and 4, as they are presented here, can have a significant function.

Examples of crossed substitutions are very much appreciated by students who are being initiated into the functional role of intonation. Here are further examples:

A Frenchman whose house is in Nice would say

J'ai vendu / ma maison // en Espagne.

If, on the other hand, his house is in Spain, he would say

J'ai vendu // ma maison / en Espagne.

One who says

J'ai peint / la jeune fille // en noir.

would be thought a practical joker. If he wants to be recognized as a painter, he must say

J'ai peint // la jeune fille / en noir.

Examples of crossed substitution do not, however, illustrate the essential role of level 4 in opposition to level 3, as well as do sequences in "echelon" formation, such as the following series of phrases:

Si Jean-Marie / nous invitait // on s'y rendrait.

Si Jean-Marie / nous invitait / à déjeuner // on s'y rendrait.

Si Jean-Marie / nous invitait / à déjeuner / à Montparnasse // on s'y rendrait.

Si Jean-Marie / nous invitait / à déjeuner / à Montparnasse / avec son frère // on s'y rendrait.

Clearly, the role of level 4 is to unite small sense groups into one large sense group which is not the last one in the sentence: whence the terminology "minor continuation" and "major continuation." Here the major continuation curve (4) gives the feeling that the preceding small units which have minor continuation curves (3), belong to the larger units which end at level 4.

We may note in passing that in French the contrast between major and minor continuations is regularly and clearly observed. In English this contrast is neither clearly expressed nor well observed; for a foreigner, it leads to ambiguity. We have shown this in the *French Review*, October 1961, by objectively comparing the intonation of Simone de Beauvoir with that of Margaret Mead.[1]

MINOR CONTINUATION, ITS PECULIARITY

Of all the intonation curves we are analyzing here, that of minor continuation (2-3) is the only one without a fixed direction. It can fall as well as rise, when it is followed by a curve which rises to a higher level; for example, when it precedes a major continuation (4), a question (4_+), or an implication (4_-). In [si se zø] of Figure 2, the alternative for minor continuation to fall is indicated by a dotted line. This fall serves simply, it seems, to break the monotony, to vary the melodic line; it has no significant function. Of the 187 minor continuations of Simone de Beauvoir mentioned above,[1] 172 are rising and only 15 are falling.

Structure 8 (Figure 3) offers us, in *Si Marie*, an example of a minor continuation which can fall as well as rise since it is followed by a higher level, and in on dira an example of a minor continuation which can only rise because it is followed by a lower level.

IMPLICATION

Structures 9 and 10 oppose va manger, spoken affirmatively, to va manger spoken with implication, that is to say here, with a comment, unexpressed by words yet understood by intonation, on Jean-Marie's mental or physical state. The parenthesis which can follow an implication (here, malgré tout), and which explains in part the implied comment, is not generally expressed aloud. Implication is very frequent in everyday conversations. If the person spoken to is acquainted with the subject of the conversation, rarely is it deemed necessary to dot all the i's and cross all the t's.

CURVES RISING TOWARD 4

Implication has a rising curve which normally terminates above the level (3) of minor continuation; it is therefore noted as rising to level 4. However, implication does not have the same shape as the rising question, which also rises to level 4 (structures 1 and 11, Figure 3). Auditory tests show that these two rising intonations can always be distinguished from one another. The question curve rises at an ever-increasing angle, whereas the implication curve rises to a plateau -- thus its rising angle decreases, ending with a slight fall and a notable lengthening of the syllable. We have therefore designated the question as 4_+, and the implication as 4_-. Major continuation, which is also designated as rising to level 4, but without a plus or a minus (structures 6 and 8, Figure 3), has a curve which, in French, is intermediate between the question and the implication: it rises steeply at first, then the angle of rise decreases, and it ends on a plateau. It can be distinguished auditorily from the question and the implication, although with less facility than these last two from each other. This distinction is not, however, indispensable, since a major continuation cannot be opposed to a question or an implication in complete sentences; these last two curves normally come at the end of a sentence, while a major continuation never ends a sentence.

We should further add that the graphic curves given to the three rising intonations -- the question, the major continuation, and the implication -- represent approximately the intonation shape of the last vowel of the sense group: an increasing angle of rise for questions, a decreasing angle ending in a plateau for major continuations, and a decreasing angle which reaches a plateau and ends in a slight fall for implications.

EXCLAMATION

In structures 12 and 13, Figure 3, the intonation of rising questions is opposed to that of falling exclamations. The two curves of Quelle horreur are essentially the reverse of each other: just as the first curve must rise above level 3 to be identified as a question, the second one must fall from a point above level 3 -- that is, from level 4 -- to be identified as an exclamation. Evidence for this statement lies in the fact that if a falling Quelle horreur had its starting point below the level 3 of Il cria -- that is, at level 2 -- it would sound like a finality statement and carry no exclamative meaning.

It is not unusual to hear a sort of exclamation with a rising rather than a falling intonation. In that case, we are not dealing with a pure exclamation but rather with an implication to which a certain emotion has been added. This is indicated by the fact that rising exclamations regularly assume the curve of an implication.

CURVES DESCENDING FROM LEVEL 4

We have, then, three intonations which begin at level 4, as well as three that rise to level 4. But the behavior of the two groups is not comparable. Whereas the three rising curves, as we have just seen, differ enough phonetically to be distinguished auditorily from one another, the three descending curves do not. Auditory tests in which all is neutralized but the melody of the sentence were inconclusive; the descending curves of command, interrogation, and exclamation were not clearly distinguishable from one another. Auditory tests using homophones gave similar results: the intonation curves of *Quelle tombe*! (What a tomb!), *Quelle tombe*? (Which tomb?), and *Qu'elle tombe* (Let her fall.), spoken without emphasis by subjects from various regions of France, were neither sufficiently nor consistently different; their distinction in normal usage is uncertain. In any case, this distinction would almost always be redundant, the syntax in these constructions being particularly distinctive. An interrogation normally begins with an interrogative word such as *quand*? *où*? *qui*? *comment*? while a command never does.

It should be noted, however, that differences of intonation among the three curves descending from level 4, as we have shown them in Figure 2, can be spoken and interpreted correctly when the speaker makes a special effort at good diction. The author of this article and his wife administered the test of [kɛltɔ̃b] to one another, and both passed it without hesitation, even though their idiolects are not the same, one being from Paris, the other from Lyon.

PARENTHESIS

Structures 14 and 15 (Figure 3) oppose, in their second sense group, the intonation of question (14) to that of parenthesis (15). In structure 14, one asks whether Mary is there, while in structure 15, one asks Mary who is the person that is there.

A parenthesis is not always expressed by a low plateau, as in structure 15. To show this, we can return to structures 10 and 11 (Figure 3). The intonations indicated for malgré tout are phonetically different in level: 1-1 in structure 10, following an implication (or a finality), vs. 4-4 in structure 11, following a question, but they have the same parenthetical meaning, the same flat shape, and they are in complementary distribution -- the low parenthesis appears after descending intonations or at a terminal descending appendage (implication), whereas the high parenthesis, or "echo," occurs after ascending intonations, using as its point of departure their last high note. The echo, is not, therefore, a new intoneme, but an allotone of the intoneme of parenthesis, whose shape is always flat, and whose intonation level is determined by the curve which precedes it.

The echo is not found only after a question (4+), even though no other case has occurred in our statistical analysis of conversations, plays, and speeches. It is possible to find it, for example, following levels 3 and 4. The following example is somewhat far-fetched, but it demonstrates that the echo may operate at more than two levels:

Si Marie (2-3), *enfin* (3-3), *vous invite* (2-4), *dit-il* (4-4), *on dira* (2-3), *qu'on accepte* (2-1), *hélas* (1-1). *N'est-ce pas* ($2\text{-}4_+$), *Henri* ($4_+\text{-}4_+$)?

The question curve of *n'est-ce pas* should not be confused with its implication curve -- implying a request for approval -- whichplaywrights follow with a misleading question mark: *N'est-ce pas* ($2\text{-}4_-$), *Henri* (1-1).

TESTING BY FILTERED SPEECH

The tests presented in Figure 3, which use utterances that are segmentally neutralized by means of homophony, provide for each of the ten curves at least one meaningful contrast with another curve. They do not, however, provide verification that each curve can contrast with all the others. This requires the use of a test by electronic filtering, which erases phonemic distinctions, and allows only pitch distinctions (the melody of the sentence) to be heard. This filtering test has clearly shown that each of the ten curves is distinct from all the others, with the exception of the three falling curves issuing from level 4, which, while not distinct from one another, form a group which contrasts with all the others.

VI. CONCLUSION

The ten most frequent intonation curves of French have been determined by statistical survey of varied material, and have been studied, (a) by a spectrographic analysis of fundamental frequency, as related to intensity and duration; and (b) by auditory tests in which distinctions of meaning are based on intonation alone.

These ten curves seem to fall into seven distinctive classes which we propose to call "intonemes" -- 4 rising classes: (a) minor continuation,

(b) major continuation, (c) question, (d) implication; two descending classes: (e) finality, (f) interrogation, command and exclamation, which are not distinctive among themselves; and a class of plateaus: (g) the parentheses, allotones of which are in complementary distribution.

There is a practical advantage in presenting the distinctive traits of the seven intonemes on a scale of 4 pitch levels, each level serving as a point of reference to a contiguous level -- level 2 is chosen arbitrarily and according to the speaker's voice, levels 1 and 3 are perceived relatively to level 2, and level 4 is perceived relatively to level 3.

The schematic and numerical representation of these curves becomes a problem only when they have the same direction -- rising to or falling from the same level. Thus the three falling curves issuing from level 4, not being distinctive among themselves, but only as a group, can be represented either intonemically by the same descent for all three, or phonetically, as in Figure 1, by descending curves (concave, straight, and convex) which suggest their characteristic shape. Numerically, they are all represented by the same change of level (4-1). The three rising curves which aim at level 4, being distinctive among themselves, must be represented schematically by different curves, to suggest their phonetic differences: for example, a curve rising at an increasing angle, a curve rising at a decreasing angle, and a decreasing angle of rise followed by a decline. Numerically, they can be distinguished by representing the increasing angle by a terminal (+) and the decline by a terminal (_).

These results are summarized on the following table:

THE TEN MOST FREQUENT FRENCH INTONATIONS

Significant function	Intoneme	Distinctive trait
1. Minor continuation	A	2-3
2. Major continuation	B	2-4
3. Question (Yes? No?)	C	2-4$_+$
4. Implication	D	2-4$_-$
5. Finality	E	2-1
6. Interrogation	F	4-1 Curves not distinctive from one another
7. Command		
8. Exclamation		
9. Parenthesis	G	1-1 Curves with complementary distribution
10. Echo		4-4

Footnotes for Delattre, "The Ten Basic Intonations of French"

1. For a graphic illustration of intonation, based on this technique, see "La leçon d'intonation de Simone de Beauvoir, étude d'intonation déclarative comparée," *French Review*, 36, 1: 59-67. 1961.

2. Eléments de Linguistique Générale, Paris, Colin, p. 26, 1960.

3. "Intonation: levels *vs*. configurations," *Word*, 7: 199-210. 1951.

4. The linguistic value of the ten intonations studied here is only *potential*, since in practice intonation is not always made use of, either because one does not always express oneself with maximal clarity, or because intonation happens to be redundant, grammar or context fulfilling the same function.

Figure Legends for Delattre, "The Ten Basic Intonations of French"

Figure 1. The ten most frequent intonations of French, presented schematically on a four-level scale.

Figure 2. On the left, a graphic representation of the actual variations of fundamental frequency in a dialogue illustrating the ten basic intonations of French. (Male voice with a speaking range of 9 tones [F sharp, 92 cps, to C, 261 cps.]) On the right, a schematic representation of the same intonations on a 4-level scale.

Figure 3. Schematic illustrations of pitch "minimal pairs" -- pairs of segmentally homophonic utterances the two members of which are meaningfully distinguished from one another by intonation alone.

INVESTIGATING THE ACOUSTIC CUES OF DISTINCTIVE FEATURES

If a distinctive feature is a perceptual unit of phonology which can transform by commutation one phoneme into another and is shared by all the members of one or more categories of phonemes having either the same place of the same manner of articulation, it can only be known indirectly through its articulatory and acoustic correlates.

The acoustic manipulation of speech patterns on a sound synthesizer makes it possible to isolate, transform, combine, add to, and subtract from acoustic features until a phoneme, morpheme, or word has changed to another. It offers, therefore, a means of testing the distinctive power of acoustic cues in isolation and in combination. Since it is not possible to analyse, dissect, isolate, and test separately the articulatory correlates of distinctive features, the most objective approach to the nature of distinctive features appears to be through their acoustic correlates.

INVESTIGATING THE ACOUSTIC CUES OF
DISTINCTIVE FEATURES

An attempt is made here to describe the acoustic correlates of distinctive features of French consonants (let us call them for short: distinctive cues, or distinctive combinations of cues that are obtained by manipulation of synthetic speech. We chose to analyse French rather than English because it has consonantal constrictions in the pharynx that produce very characteristic acoustic traits without which an acoustic picture of a language would be too restricted.

Figure 1 is a chart of the spectographic patterns of French consonants in intervocalic position between vowels /a/: /apa/, /ata/, etc. Those

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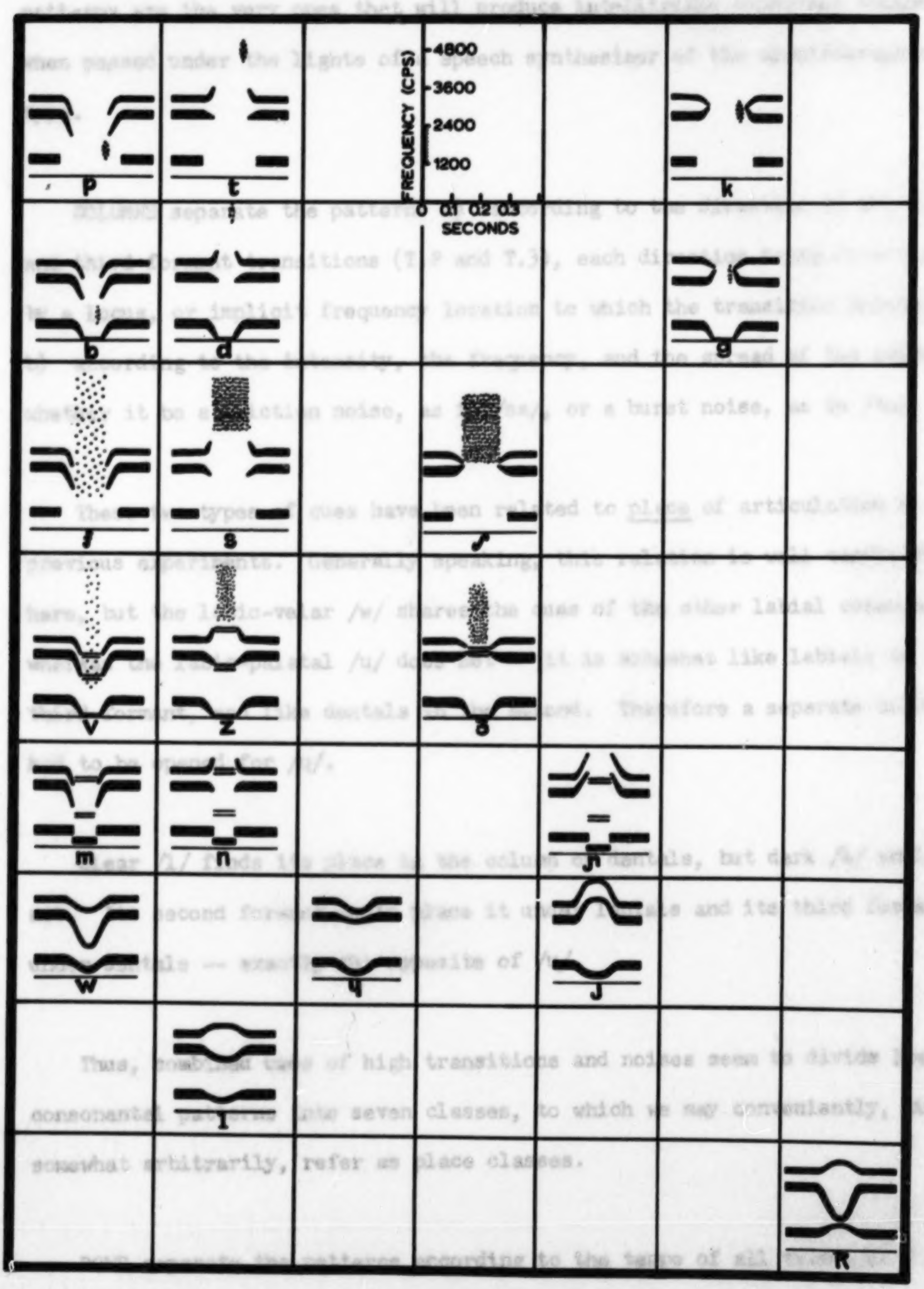
4800
3600
2400
1200
FREQUENCY (CPS)
0 .1 .2 .3
SECONDS
p
t
k
b
d
g
f
s
ʃ
v
z
ð
m
n
ŋ
w
ɥ
j
l
R

Figure 1

patterns are the very ones that will produce intelligible consonant sounds when passed under the lights of a speech synthesizer of the spectrographic type.

COLUMNS separate the patterns a) according to the direction of second- and third-formant transitions (T.2 and T.3), each direction being determined by a Locus, or implicit frequency location to which the transition points; b) according to the intensity, the frequency, and the spread of the noise, whether it be a friction noise, as in /sa/, or a burst noise, as in /ta/.

These two types of cues have been related to *place* of articulation by previous experiments. Generally speaking, this relation is well confirmed here, but the labio-velar /w/ shares the cues of the other labial consonants, whereas the labio-palatal /ɥ/ does not -- it is somewhat like labials in the third formant, and like dentals in the second. Therefore a separate column had to be opened for /ɥ/.

Clear /l/ finds its place in the column of dentals, but dark /ɫ/ would not. Its second formant would place it under labials and its third formant under dentals -- exactly the opposite of /ɥ/.

Thus, combined cues of high transitions and noises seem to divide French consonantal patterns into seven classes, to which we may conveniently, but somewhat arbitrarily, refer as place classes.

ROWS separate the patterns according to the tempo of all transitions,

Friction Noise

f Higher Spread Weak
θ High Spread Weak
ç Mid Narrow Mid
ɣ M.L. Narrow Mid
x Low Narrow Mid
s High Wide Strong (Noise cues apply
ʃ Mid Wide Strong only to ptk, bdg,
f Low Spread Weak fsʃ,vzʒ)

PLACE CUES →

MANNER CUES ↓

								Tr. 2				Tr. 3				Noise		
								Locus at 700	Locus at 1700	Locus at 2000	Locus at 3000	Locus at 2000	Locus at 2200	Locus at 2700	Locus at 3500	p-f Low Spread Weak	k-ʃ Mid Wide Strong	t-s High Wide Strong
		w	m	v	f	b	p	x				x				x		
	l		n	z	s	d	t		x					x				x
		ɥ							x				x					
				ʒ	ʃ					x			x				x	
		j	ɲ								x				x			
						g	k				x		x				x	
						g̥	k̥				(x)		x				x	
R								x						x				

			x	x	x	x	x	Fast Transitions ⟩ vs Slow Transitions ⟩
	x	x		x	x	x	x	Neg. Trans.1 (Initially Rising Formant-1)
x								Pos. Trans.1 (Initially Falling Formant-1)
			x					Zero Trans.1 (Straight Formant-1)
x	x	x	x	x	x			Links vs no Links
x	x	x	x	x	x			High Links
x	x	x	x					Low Link
				x	x			Turbulent Link vs no Turb. Link
(x)	(x)	(x)	(x)	(x)				(Periodic Links)
			x					Discontin. Periodic Links vs Continuous P.L.
		x	x					Low Link is at 250 cps
	x							Low Link is at 400 cps
x								Low Link is at 700 cps
(x)	(x)	(x)	(x)					Any Periodic Link causes "Voicing"
					x		x	Long Hold vs Short Hold
					x		x	Cutback vs no Cutback
					x		x	No Voicebar vs Voicebar
					x		x	Strong Noise (Burst or Friction) vs Weak Noise
				x				High Continuous Periodic Link vs no H.C.P.L.
					(x)		(x)	(Aspiration vs no Aspiration)

Figure 2

the direction of first transitions, and what occurs during the hold, (or closure) -- whether or not there is a "link" (an acoustic bridge) during the hold, whether the link is turbulent, periodic, or both, whether it is continuous or discontinuous, and what the frequency of the low links are.

Previous research had shown that all those cues are related to manner of articulation. This is largely confirmed here -- the eight rows may conveniently be referred to in traditional terms of manners of articulation.

It could appear sufficient for consonant R, in the extreme bottom right slot, to be classed only in a separate place, and not also in a separate manner of articulation -- it is pharyngeal; its constriction is produced by backing the root of the tongue toward the vertical wall of the pharynx, according to recent motion picture X-rays. Yet we find it more appropriate to put it also in a separate manner class. The positive first formant transition which characterizes it(and distinguishes it from the other French consonants)is found in all pharyngeal sounds, whether plosive, fricative, glides, voiced, voiceless, high pharynx or low pharynx. "Pharyngeal" must then be taken as a manner term, in opposition to "mouth", all pharyngeal sounds having a positive transition in the first formant, all mouth sounds (oral) having a negative transition in the first formant.

Figure 2 is a table of the acoustic cues of the chart column (on the left) and of the chart rows (on the right), which we find convenient to call acoustic cues of place (on the left) and acoustic cues of manner (on the right).

Figure 2 shows that there are three kinds of acoustic cues of PLACE: 1. The direction of the second-formant transition (as described by its LOCUS, the implicit frequency to which a formant transition points). 2. The direction of the third-formant transition. 3. The frequency, band-width, and intensity of the friction-noise (in fricatives) or burst-noise (in plosives). The third kind does not apply to nasals and glides, obviously.

(The classification of noise cues into: high, mid, and low being a considerable simplification, the actual complexity of friction cues is shown in the upper left corner of Table 2. The comparison of frictions in various languages should help to understand their distinctive traits.)

Altogether there are 11 acoustic cues of place -- four in second formants, four in third formants, and three in noises.

The X's indicate which distinctive combinations of cues characterize the place of articulation of each column -- there are 8 distinctive combinations of cues in French.

In every column the place of articulation is identified by either three (plosives and fricatives) or two cues (nasals and glides), never by a single one. Therefore no single place cue is distinctive; only combinations of two of three place cues are distinctive.

Acoustic cues of MANNER of articulation are considerably more complex than those of place. Figure 2 describes 20 manner cues for French. But the last one, aspitation, is almost negligible in French, and two others (in parentheses) are redundant. This leaves 17 manner cues.

The acoustic cues of MANNER of articulation are considerably more complex than those of place. Their grouping into distinctive combinations of cues does not correspond to the rows of the chart; the manner class of each row will have to be described not by a single "distinctive combination of cues" but by several.

Figure 2 describes 20 manner cues for French. But the last one, aspiration, is almost negligible in French, and two others (in parentheses) are redundant. This leaves 17 manner cues. At the present stage of our research, which is not yet definitive, these 17 cues seem to resolve themselves into 7 pairs of oppositive combinations of cues, or 14 separate combinations of cues, only 10 of which are needed as positive features to describe the eight manner-rows of the chart. (It is economical to consider first all classes of consonants as voiced and apply later the unvoicing cues to the only two classes in which voicelessness is distinctive). The 10 distinctive combinations of manner cues for French are described below:

1. Fast transitions, and its concomitant cue:
   No continuous low link
2. Slow transitions, and its concomitant cue:
   Continuous low link, and its concomitant cue:
   Continuous high links
3. No links, and its concomitant cue:
   Burst of noise

4. Turbulent link, and concomitant cues:
    No low link
    High periodic links
5. Negative transition-1
6. Positive transition-1, and concomitant cue:
    Low link at 700 cps
7. Discontinuous links, and concomitant cue:
    Zero transition-1
8. Low link at 250 cps
9. Low link at 400 cps
10. Long hold, and its concomitant cues:
    Cutback of transition-1
    No voicebar
    Strong noise (friction or burst)
    No high periodic link

The traditional manner classes of French consonants are identified by two, three, or four of those ten distinctive combinations of acoustic cues:

Voiceless plosives: 1, 3, 5, 10

Voiced plosives: 1, 3, 5

Voiceless fricatives: 1, 4, 5, 10

Voiced fricatives: 1, 4, 5

Nasals: 1, 7, 8

Central glides: 2, 5, 8

Lateral glides: 2, 5, 9

Pharyngeal glides: 2, 6

To conclude, let us take an example. The /s/ phoneme is identified in French by five distinctive combinations of cues, one for place, the distinctive combination which might be called "dental" (3 cues), and three for manner of articulation, the distinctive combinations 1 (2 cues), 4 (3 cues), 5 (1 cue), and 10 (5 cues).

A COMPARISON OF SYLLABLE LENGTH CONDITIONING AMONG LANGUAGES

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Relative length is one of the elements which determine the perceptual "weight" of a syllable and give it prominence.

As a first step towards comparing the distribution of syllable weight in English, German, Spanish, and French, we are investigating the length of syllables in those languages and the factors which correlate with and condition this length.

It is generally believed that, in the perception of syllable weight, three subjective ingredients may play a part -- loudness, pitch, and length. The reason for beginning this investigation with length is that it is relatively simple -- measurements of duration can yield clear figures. The other factors of syllable weight offer such complexity that it was thought better to postpone comparing their relation to syllable weight among languages until duration was sufficiently understood. The contribution of pitch to syllable weight may depend, for instance, not only on the average frequency of one syllable relative to others, but on the contour of this frequency variation, its rise, its fall, its proportion of fall and rise. The contribution of loudness to syllable weight may depend, not only on vowel intensity (or overall amplitude) and its onset and decay, but on certain features of the consonants such as the length of closure and the speed of opening which are not measurable in decibels, yet depend on the energy expended.

To avoid obscuring the results of our measurements, we shall limit this investigation, for the most part, to three conditioning factors -- syllable weight, syllable position -- and syllable type -- and we shall consider them only as binary factors. Thus, in matters of weight, syllables which receive a primary stress will be called "stressed," and all others will be called "unstressed;" in matters of position, syllables which stand last of sense-group will be called "final,"and all others will be called "non-final;" and in matters of type, syllables which end with one or more consonants sounds will be called "closed," and all others will be called "open."

Before comparing syllable lengths and length-conditioning among the four languages mentioned above, let us describe briefly the experimental procedure which was followed in gathering appropriate syllable length data.

For each of the four languages, five minutes of extemporaneous speech by native speakers was selected with the purpose of obtaining naturalness and fluency in expression with relatively similar speeds of delivery. Spectrograms of the material were made at the scale 2000 cps per inch, with narrow-band filtering and amplitude display.

By referring to both the original recordings and the spectrograms, a broad phonetic transcription was made, stressed syllables were identified, and sense-group boundaries were determined.

Then the difficult matter of syllable division was approached. It raised two obstacles: a) dividing syllables had to be uniform for all languages, yet certain characteristics of each language had to be taken into account; b) scientifically speaking, syllabic division generally occurs during the closure of the closest consonant between vowel peaks, so that a portion of that closest consonant is in the first syllable and the other portion in the second syllable. But practically we have to divide before or after such consonants and a certain compromise must be accepted.

On the whole, we applied the principles of syllabication of De Saussure (Cours de Linguistique Générale). They are based on aperture sequences. Consonants fall fairly well into five different degrees of aperture. These five categories nearly coincide with the traditional division by manner of articulation. From greatest to smallest aperture, they are: stops, nasals, fricatives, liquids, and semiconsonants. Thus the abstract syllable [pʃljawrst], with eight consonants and one vowel, is pronoumceable because of uninterrupted increasing and decreasing apertures.

According to De Saussure, syllabic division occurs before the closest consonant of an intervocalic series. Thus the French word *patrie* will be divided *pa*-*trie*, with the consonant group *tr* belonging to the second syllable, since the *t* is of smaller aperture than the *r*. If we reverse the order of the two consonants, as in the word *partie*, the syllabic division takes place between the two consonants: *par*-*tie*, with the *r* belonging to the first syllable and the *t* to the second. If two consonants are of the same aperture, the division is made between them, as in the word *ac*-*tif*. One must take care, though, in dealing with languages that have strong consonantal anticipation because they can be at slight variance with these rules.

In both Spanish and French, syllable division was made irrespective of word boundaries within the sense-group, but in English and German, where there is strong consonantal anticipation, we retained word final consonants with the last syllable of the word. Thus in Spanish *el hombre* and in French *il apprend*, the *l* is carried over from the first word to the initial vowel of the second. But in such words as English in evening and German zum einen, syllable division was made between the two words. If this favored the number of closed syllables in German and English, there was an appropriate compensation in the fact that, within the word, the intervocalic consonant was always counted as belonging to the syllable of the following vowel -- giving, for instance, was divided gi-ving even though such an intervocalic consonant has a larger portion in the first syllable than in the second in a Germanic language as compared to a Romance language.

Another problem presented itself -- that of locating the frontier between vowels and consonants on spectrograms. Recent research having shown very clearly that formant transitions are related to the perception of consonants and not to that of vowels, the division was made accordingly -- after the transitions in the sequence consonant-vowel, and before the transitions in the sequence vowel-consonant. It is worth noting here that all measurements made in the past on kymograms and oscillograms are obsolete since they counted as part of the vowel everything but the actual consonant closures. The fact is that consonants are perceived, not by their closure portion only, but also, and more, by the opening and closing movements which precede and follow their closure. The arresting and releasing formant transitions, which reflect those closing and opening articulatory movements, are generally sufficient to produce excellent consonants in the synthesis of artificial speech.

Measurements to the closest centisecond having been made, three by five cards were prepared for each syllable, to record its phonetic content, its length, its degree of stress, its structural shape in C and V designation, and its position in the sense-group. With this information extracted, tables were drawn up to compare the relation of syllable duration to syllable weight, syllable location, and syllable type among the four languages.

Table 1

COMPARISON OF SYLLABLE LENGTHS (in cs)
UNDER THE EFFECTS OF SYLLABIC WEIGHT, PLACE, AND TYPE

			English	German	Spanish	French
Stressed	Final	Closed	40.81	36.15	32.13	34.12
		Open	33.45	29.75	24.50	24.57
	Non-final	Closed	25.88	24.56	25.88	
		Open	19.19	19.72	20.23	
Unstressed	Final	Closed	25.62	27.81	23.03	
		Open	21.24	17.69	18.52	
	Non-final	Closed	15.50	17.51	19.27	19.19
		Open	12.02	13.22	18.16	13.74

The complete data of syllable length in the four languages under the combined effects of syllable weight (stressed or unstressed), syllable position in the sense-group (final or non-final), and syllable type (closed or open) are gathered here in a single picture. Table 1 shows clearly eight different categories of syllable length in English, German, and Spanish, but only four categories in French, where all stressed syllables are final, and therefore non-final stressed syllables and final unstressed syllables are not found. Many observations could be made with the help of this single table, but because of its complexity, additional tables will be extracted from it, either directly or by further averaging of averages, for each worthwhile comparison among the four languages. Our main purpose, let us recall, is to characterize each of the four languages by comparison with the other three.

There is one remark that can be made only with the help of this general table. The three languages with variable place of stress, English, German, and Spanish, show remarkable agreement of syllable length for stressed non-final syllables. Where they disagree is in the range of divergence from this common condition to other conditions. Divergence from stressed non-final moves in wide steps in English -- upwards to final stressed and downwards to final unstressed and non-final unstressed. The steps in divergence from the non-final stressed condition are less wide in German, and are comparatively narrow in Spanish. Degrees of divergence from a common norm seem to correlate with the ratio of intensity variations between stressed and unstressed vowels. The difference of vowel intensity (measured by over-all amplitude and perceived by loudness) between stressed and unstressed syllables is highest in English, (about 4.4 db), less high in German, (about 2.2 db), lower in Spanish, (about 1.3 db), and lower yet in French, (about .5 db in favor of the unstressed syllable). (It is on purpose that this comparison of intensities was made between stressed and unstressed vowels, not syllables. Syllable intensity, as was noted earlier, depends not only on vowel amplitude but on several consonant features.)

Table 1-A

RATIOS OF SYLLABLE LENGTHS BETWEEN CLOSED SYLLABLES AND OPEN SYLLABLES

			English	German	Spanish	French
Stressed	Final	Closed Open	$\frac{1.22}{1}$	$\frac{1.21}{1}$	$\frac{1.31}{1}$	$\frac{1.39}{1}$
	Non-final	Closed Open	$\frac{1.35}{1}$	$\frac{1.24}{1}$	$\frac{1.28}{1}$	
Unstressed	Final	Closed Open	$\frac{1.21}{1}$	$\frac{1.57}{1}$	$\frac{1.24}{1}$	
	Non-final	Closed Open	$\frac{1.29}{1}$	$\frac{1.32}{1}$	$\frac{1.06}{1}$	$\frac{1.40}{1}$

If Table 1 shows great divergence among the languages under the effects of syllable weight and syllable position, Table 1-A shows, on the contrary, considerable similarity among the languages under the effect of syllable type. The ratio of syllable lengths between closed syllable and open syllable in the 14 pairs of figures on Table 1-A is somewhat constant for all conditions and all languages. This ratio is close to 1.30 to 1 in all cases, except for German unstressed final which is higher: 1.57 to 1, and Spanish unstressed non-final which is lower: 1.06 to 1. Statistical data on the consonant to vowel ratio and the proportion of closed and open syllables tends to support these two exceptions. There is about 1.2 consonant per vowel in German, and only .8 consonant per vowel in Spanish. Closed syllables are in a proportion of 68 percent in German, but only 28 percent in Spanish. (These figures are based on the analysis of 2000 syllables of varied material in German and in Spanish.) This takes care of the negative side. On the positive side, the fact that the ratio of duration from closed to open syllables is nearly constant, no matter how long or how short the syllable is conditioned to be, is an interesting indication that the ratio of time taken by vowels and consonants in a syllable remains somewhat the same under all circumstances in all four languages -- if a syllable is longer than another, both its consonants and its vowel are proportionately longer.

Table 2

MAXIMAL RANGE OF SYLLABLE LENGTH VARIATION
(COMBINED EFFECT OF WEIGHT, POSITION, AND TYPE)

	English	German	Spanish	French
Stressed, Final, Closed	40.81	36.15	32.13	34.12
Unstressed, Non-final, Open	12.02	13.22	18.16	13.74
Ratio to 1	3.39	2.73	1.77	2.48

Table 2 presents syllable length averages under the combined effects of syllable weight, syllable position, and syllable type. In other words, this table shows how wide is the maximal range and maximal ratio of syllable length for each of the four languages. On Table 2, as on all following tables, ratios are as indicated just below, and to the right of, the absolute duration averages.

English and Spanish occupy the two opposite ends of the spectrum with respective ratios of 3.39 to 1 and 1.77 to 1 -- a very significant difference if we consider that both languages have intensity stress and variable place of stress, and are therefore in the same stress category. Syllable duration emerges as one of the sharpest differences between these two languages.

German and French, with ratios of 2.73 to 1 and 2.48 to 1, are still well distinguished from English and Spanish by their range of syllable length, but they are not distinguished from one another.

Note that in our tables, unstressed syllables comprise all syllables that do not receive the primary stress. If subdivision into, for instance, three classes of weak stress were made, French and Spanish would not be measurably affected, whereas English would show a much wider range of syllable lengths and would be even more distinct from the other languages.

In short, from this table of maximal ranges, syllable length emerges as an important feature in the characterisation of languages. One receives very different rhythmic impressions from languages whose longest syllables (as a class) are about three and a half times longer (English), two and a half times longer (German, French), or one and a half times longer (Spanish) than the shortest syllables (as a class).

Table 3

OVERALL EFFECT OF SYLLABLE WEIGHT ON SYLLABLE LENGTH

	English	German	Spanish	French
Stressed syllable	29.82	27.54	25.68	29.34
Unstressed syllable	18.59	19.06	19.75	16.46
Ratio to 1	1.60	1.44	1.30	1.78

Table 3 presents length averages of all the stressed vs all the unstressed syllables for five minutes of speech in each language. (The category of "unstressed" includes all the syllables that do not receive the primary stress.) The effect of stress on syllable length can be shown either by the difference of length between stressed and unstressed syllables or by the length ratio of stressed to unstressed syllables.

The effect of stress is clearly but not equally marked in all four languages.

Let us first compare among themselves the three languages whose place of stress is variable. Of these, English has the widest ratio of syllable lengths from stressed to unstressed. German has a narrower ratio, and Spanish the narrowest. In other words, the contrast of lengths between stressed and unstressed syllables is very sharp in English, somewhat less so in German, and considerably less so in Spanish.

As American teachers of Spanish often state that Spanish syllables are all of nearly equal length, whether stressed or unstressed, it is interesting to note that, according to our data, this is not objectively true -- a ratio of 1.30 to 1 is far from negligible. But it is not surprising that, by contrast with his own habits, an American can subjectively estimate Spanish syllables to be of equal length. In fact, as Tables 13 and 17 will show, there are large categories of Spanish syllables whose lengths are not greatly affected by stress or position -- unstressed open syllables are hardly longer in final position (18.52) than in non-final position (18.16); and non-final open syllables are only slighter longer in stressed syllables (20.23) than in unstressed syllables (18.16).

Differences of length between stressed and unstressed syllables correlate with differences of vowel intensity. As was noted earlier, in English the difference between stressed and unstressed vowels is, on the average, 4.4 db. In German it is only 2.2 db. And in Spanish only 1.3 db. In Spanish, however, the burden of stressing a syllable is taken over by consonantal features rather than by vocalic ones.

Let us now turn to French, a language whose place of stress is fixed (on the last syllable). It is French which, of the four languages, shows by far the widest ratio of lengths from stressed to unstressed syllables -- a ratio of nearly two to one. This can be explained in more than one way. One can note that it is only in French, for instance, that the stressed syllable is always conditioned by both weight and position. When those two factors combine in the other languages, as shown on Table 6, the length ratios are much higher than for either effect.

One can remark also that prominence of the stressed syllable does not rely on an excess of intensity in French, as it does in English, German, and Spanish -- the physical intensity of final syllable vowels, in French, is in fact some 10 percent lower than that of non-final syllable vowels. In giving prominence to stressed syllables, therefore, duration must take a larger share of the burden than if it were helped by intensity.

Table 4

OVERALL EFFECT OF SYLLABLE POSITION ON SYLLABLE LENGTH

	English	German	Spanish	French
Final syllable	27.78	27.85	24.54	29.34
Non-final syllable	18.15	18.50	20.88	16.46
Ratio to 1	1.53	1.50	1.17	1.78

Table 4 presents length averages of all the final syllables vs all the non-final syllables for five minutes of speech in each language.

A comparison of Tables 3 and 4 shows that, in English and Spanish, the effect of syllabic position is even stronger than that of stress -- the ratios are 1.53 and 1.17 for the effect of position vs 1.60 and 1.30 for the effect of stress. In German, the lengthening effect of position is slightly greater than that for stress; as a result, German final syllables are practically as long, and non-final syllables as short, as English ones -- the lengthening effect of syllabic position is very similar. In French the length ratio between final and non-final syllables is the same as between stressed and unstressed syllables since, there also, the effects of weight and position are always the same.

In general, on the basis of these data, one can say that with respect to length, the final position is a privileged one in all four languages. Table 8 will show that even unstressed syllables can have considerable length if they are final.

A word can be said here about the effect of the other positions on syllable length. Next in rank is the initial position, which is not so long as the final but longer than medial positions in all four languages. As to the medial positions, they tend to be longer as they approach the end of the word or the sense-group.

Table 5

OVERALL EFFECT OF SYLLABLE TYPE ON SYLLABLE LENGTH

	English	German	Spanish	French
Closed syllable	26.94	26.51	25.08	26.65
Open syllable	21.47	20.09	20.35	19.15
Ratio to 1	1.25	1.32	1.23	1.39

Table 5 presents length averages of all the closed syllables vs all the open syllables for five minutes of speech in each language.

On the average, closed syllables are longer than open ones in all four languages, and the ratios of length between closed and open syllables do not differ markedly from one language to another.

If German has a slightly higher ratio than English, and Spanish a slightly lower one, it reflects the respective ratios of consonant to vowel which are 1.2 to 1 in German, 1.0 to 1 in English, and .8 to 1 in Spanish. The slightly higher ratio of syllable lengths in French must be due to the greater number of long syllables in final position, since all final syllables are stressed in French -- in final stressed position closing consonants as well as vowels participate in the lengthening or shortening of syllables.

One might have expected to find a rhythmical equalization of syllables irrespective of their closed or open nature. This is not the case. The fact that closed syllables are longer than open ones indicates that there is no clear compensatory effect to prevent the addition of final consonants from lengthening syllables.

Table 6

COMBINED EFFECT OF WEIGHT AND POSITION
IN CLOSED SYLLABLE

	English	German	Spanish	French
Stressed, Final, Closed	40.81	36.15	32.13	34.12
Unstressed, Non-final, Closed	15.50	17.51	19.27	19.19
Ratio to 1	2.63	2.06	1.67	1.78

Table 7

COMBINED EFFECT OF WEIGHT AND POSITION
IN OPEN SYLLABLE

	English	German	Spanish	French
Stressed, Final, Open	33.45	29.75	24.50	24.57
Unstressed, Non-final, Open	12.02	13.22	18.16	13.74
Ratio to 1	2.78	2.25	1.35	1.79

Since Table 5 shows that syllable type has no marked effect to distinguish one language from another, Tables 6 and 7 eliminate the effect of syllable type and concentrate on the combined effects of weight and position.

Combining the effects of weight and position brings to light the difference between French and the three other languages. French is not affected by this combination of effects. Its ratios between stressed final and unstressed vs non-final remain the same (1.78 to 1) as they were for stressed vs. unstressed or for final vs non-final because, in French, stressed and final is one and the same effect, not two effects that add up.

In the other three languages, the effects of stress and finality add up because a stressed syllable can be either final or non-final and a final syllable can be either stressed or unstressed. Thus in English, German, and

Spanish, the range of syllable lengths from stressed final to unstressed non-final is much wider than from stressed to unstressed or-final to non-final separately.

In both Tables 6 and 7, the widest ratio is in English, the narrowest is in Spanish, and German is in between. Sharply different ratios distinguish the four languages from one another.

Table 8

OPPOSED EFFECTS OF WEIGHT VS POSITION
IN CLOSED SYLLABLE

	English	German	Spanish	Average
Stressed, Non-final	25.88	24.56	25.88	25.44
Unstressed, Final	25.62	27.81	23.03	25.49
Ratio to 1	1.01	.88	1.12	

Table 9

OPPOSED EFFECTS OF WEIGHT VS POSITION
IN OPEN SYLLABLE

	English	German	Spanish	Average
Stressed, Non-final	19.19	19.72	20.23	19.71
Unstressed, Final	21.24	17.69	18.52	19.15
Ratio to 1	.90	1.11	1.09	

Now, instead of combining the effects of syllable weight and syllable position, we shall oppose them. On Tables 8 and 9, the lengthening effect of stressing is matched with the shortening effect of non-final position, and the shortening effect of unstressing is matched with the lengthening effect of final position. These oppositions disclose that, in the three languages with variable place of stress, some unstressed syllables are, on the average, as long as stressed ones -- unstressed syllables that are in final position are nearly as long as, or even slightly longer than, stressed syllables that are not in final position. All oppositions of these two effects produce syllable durations in the neighborhood of 25 centiseconds for closed syllables (Table 8) and 19 centiseconds in open syllables (Table 9). In English, the two effects almost compensate for each other: ratios are 1.01 to 1 in closed syllable and .90 to 1 in open syllable. In German they compensate even more closely: the average ratio of closed and open syllables is .99 to 1. In Spanish, the stressed non-final syllables are but slightly longer than the unstressed final ones: the two ratios average 1.10 to 1.

Naturally, the unstressed final syllables that are as long as stressed non-final ones are not as strong or as loud -- they have much weaker consonant and vowel features than the stressed non-final. We can assume that it is because of their low loudness and in spite of their considerable length that unstressed final syllables are perceived as unstressed.

This equivalence of syllable length in unstressed final and stressed non-final indicates that it is only in French that stress is perceived exclusively by an excess of duration. In the three languages with variable place of stress, duration does not function alone -- it operates in conjunction with an excess of intensity. Adding to the preceding the fact that all unstressed syllables, in the same three languages, have weak loudness but not all have short duration, indicates that in the perception of stress loudness is primary and length secondary. (We are aware that in extreme cases duration may be perceived as loudness and intensity as length, but this does not have much bearing on what precedes.)

Let us finally observe the separate effects of weight and position on syllable length in each combination of the two other factors. These data will involve stressed syllables in non-final position as well as unstressed syllables in final position, and therefore will not concern French -- they will only compare among themselves English, German, and Spanish.

We shall begin with the effect of syllable position.

Table 10
EFFECT OF SYLLABLE POSITION
ON LENGTH OF STRESSED CLOSED SYLLABLE

	English	German	Spanish	French
Final, Stressed, Closed	40.81	36.15	32.13	
Non-final, Stressed, Closed	25.88	24.56	25.88	
Ratio to 1	1.58	1.47	1.24	

Table 11
EFFECT OF SYLLABLE POSITION
ON LENGTH OF STRESSED OPEN SYLLABLE

	English	German	Spanish	French
Final, Stressed, Open	33.45	29.75	24.50	
Non-final, Stressed, Open	19.19	19.72	20.23	
Ratio to 1	1.74	1.51	1.21	

Table 12
EFFECT OF SYLLABLE POSITION
ON LENGTH OF UNSTRESSED CLOSED SYLLABLE

	English	German	Spanish	French
Final, Unstressed, Closed	25.62	27.81	23.03	
Non-final, Unstressed, Closed	15.50	17.69	19.27	
Ratio to 1	1.65	1.59	1.19	

Table 13

EFFECT OF SYLLABLE POSITION
ON LENGTH OF UNSTRESSED OPEN SYLLABLE

	English	German	Spanish	French
Final, Unstressed, Open	21.24	17.51	18.52	
Non-final, Unstressed, Open	12.02	13.22	18.16	
Ratio to 1	1.77	1.34	1.02	

Tables 10, 11, 12, and 13 show that stressed closed, stressed open, unstressed closed, and unstressed open syllables are all, on the average, longer in final than in non-final position, but always more so in English than in German or Spanish, and more so in German than in Spanish. In other words, syllable position affects syllable duration for every degree of stress and opening, but this conditioning is relatively strong in English, weak in Spanish, and medium in German.

These four tables also show that, under the effect of syllable position, the three languages are better distinguished from each other in open syllables than in closed ones, in unstressed syllables than in stressed ones. Ratios to 1 between final and non-final positions are for English, German, and Spanish, in this order: stressed closed syllables: 1.58, 1.47, 1.24; unstressed open syllables: 1.77, 1.34, 1.02.

The latter data, taken from Table 13, emphasizes the fact that the greatest syllabic contrast between English and Spanish is not in stressed syllables but in unstressed ones -- English unstressed open syllables are much longer in final position than in non-final position (the ratio is 1.77 to 1), whereas Spanish unstressed open syllables have all nearly equal length, whether they are in final position or not.

Table 14

EFFECT OF SYLLABLE WEIGHT ON LENGTH OF FINAL CLOSED SYLLABLE

	English	German	Spanish	French
Stressed, Final, Closed	40.81	36.15	32.13	
Unstressed, Final, Closed	25.62	27.81	23.03	
Ratio to 1	1.59	1.30	1.39	

Table 15

EFFECT OF SYLLABLE WEIGHT ON LENGTH OF FINAL OPEN SYLLABLE

	English	German	Spanish	French
Stressed, Final, Open	33.45	29.75	24.50	
Unstressed, Final, Open	21.24	17.69	18.52	
Ratio to 1	1.57	1.68	1.32	

Table 16

EFFECT OF SYLLABLE WEIGHT ON LENGTH OF NON-FINAL CLOSED SYLLABLE

	English	German	Spanish	French
Stressed, Non-final, Closed	25.88	24.56	25.88	
Unstressed, Non-final, Closed	15.50	17.51	19.27	
Ratio to 1	1.67	1.40	1.34	

Table 17

EFFECT OF SYLLABLE WEIGHT ON LENGTH OF NON-FINAL OPEN SYLLABLE

	English	German	Spanish	French
Stressed, Non-final, Open	21.24	17.69	20.23	
Unstressed, Non-final, Open	12.02	13.22	18.16	
Ratio to 1	1.59	1.49	1.11	

Tables 14, 15, 16, and 17 are concerned with the effect of stress on all positions and types of syllables. They show that final closed, final open, non-final closed and non-final open syllables are all, on the average, longer in stressed than in unstressed position, but generally more so in English than in German or Spanish, and more so in German than in Spanish. In other words, syllabic stress affects syllablic duration for every position or type of syllable, but this conditioning is relatively strong in English, weak in Spanish, and medium in German.

Again it is of special interest to compare English and Spanish. It is not in final position that those two languages are best distinguished from each other by the degrees of stress, but in non-final position, (according to Table 17) -- in English, non-final open syllables are much longer when stressed than when unstressed (the ratio is 1.59 to 1), whereas in Spanish, non-final open syllables are only slightly longer when stressed than when unstressed (the ratio is 1.11 to 1).

Now if we compare our observations about Tables 10 to 13 with those about Tables 14 to 17, we are in a position to conclude with more embracing remarks concerning the role of syllable length in the phonetic characterization of languages, and its utility in the teaching of foreign languages.

The degree of stress of non-final syllables, and the position of unstressed syllables, affect greatly the length of English syllables, somewhat less the length of German syllables, and surprisingly little the length of Spanish syllables. On the matter of syllable length, therefore, we have learned that English, German, and Spanish are maximally distinguished from each other in unstressed and non-final syllables. This is of considerable importance for teaching. The American instructor of those languages must pay much more attention to the articulation of unstressed and non-final syllables than to the stressed and final ones. This, of course, applies even more to French.

To conclude, an attempt is made, on Figure 1, to give a visual representation of the relative syllable durations and vowel intensities of a typical chain of syllables in each of the four languages. Durations are calculated by averaging the closed and the open syllables on the basis of their proportions in each language: in German 63 per cent closed, 37 per cent open; in English 60 per cent closed, 40 per cent open; in Spanish 28 per cent closed, 72 per cent open; in French 24 per cent closed, 76 per cent open. Differences of vowel intensity between stressed and unstressed syllables are based on statistical figures given earlier. Relative to the stressed syllables, the unstressed ones are on the average 4.4 decibels down in English, 2.2 decibels down in German, 1.3 decibels down in Spanish, 0.5 decibels up in French. Thus the difference is represented as maximal in English, as 2.2 / 4.4 as large in German as in English, and as 1.3 / 4.4 as large in Spanish as in English. It must be kept in mind, however, that vowel intensity alone is not representative of syllable loudness, since consonantal features that are not measurable in decibels also play an important role in the subjective impression of syllable loudness. The role of consonants seems to be unusually strong in Spanish stress, perhaps to compensate for the lack of marked length and intensity differences, as further research may show.

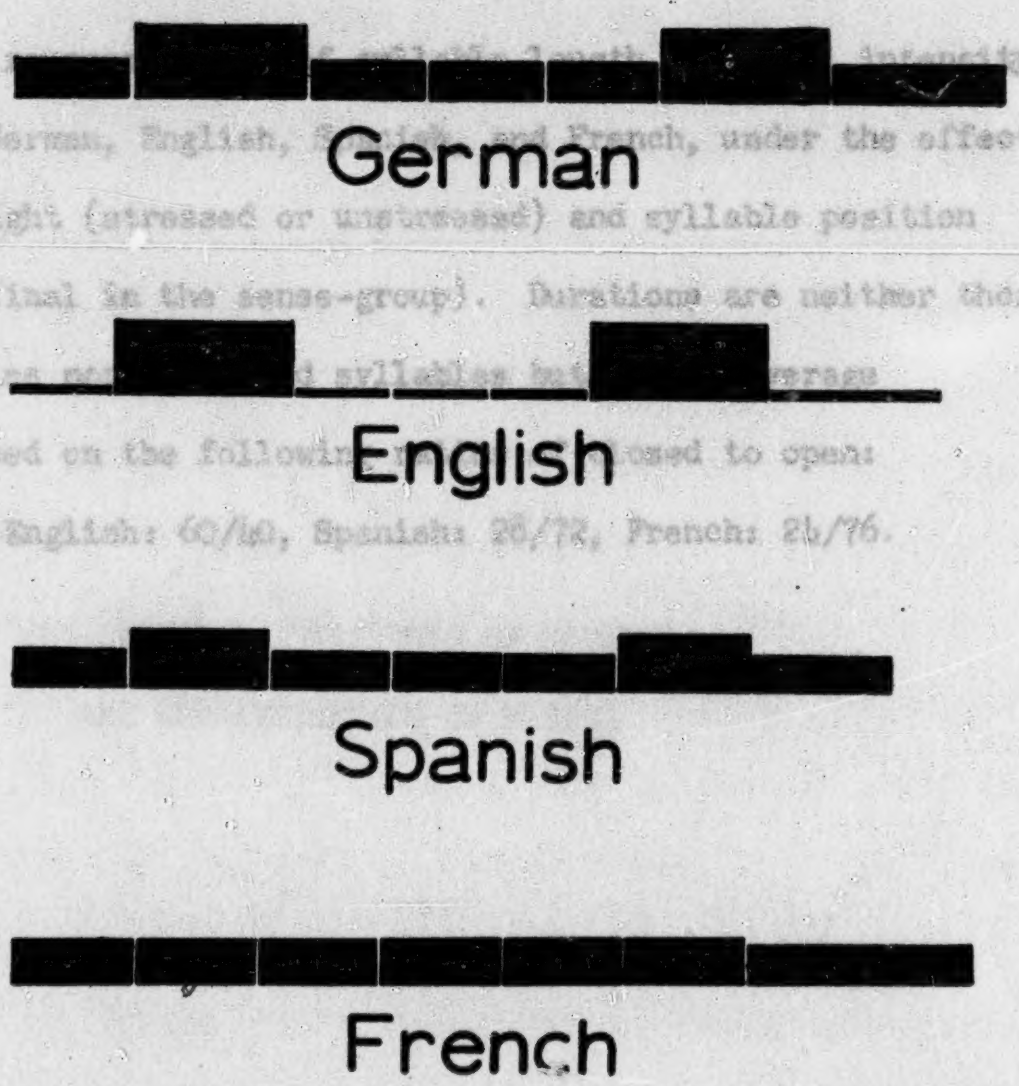

Figure 1

Legend for Figure 1

A visual representation of syllable length and vowel intensity variations in German, English, Spanish, and French, under the effects of syllable weight (stressed or unstressed) and syllable position (final or non-final in the sense-group). Durations are neither those of open syllables nor of closed syllables but of the average of the two, based on the following ratios of closed to open: German: 63/37, English: 60/40, Spanish: 28/72, French: 24/76.

THE PHYSICAL ATTRIBUTES OF SPEECH AND THE AESTHETICS OF FRENCH [1]

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Our understanding of the physical nature of speech has been completely revolutionized by the research done on this subject over the past fifteen years. This research has provided answers to the most urgent questions concerning the physical elements that, when taken together, make it possible to perceive syllables in the speech chain. These elements are called ACOUSTIC CUES, and can be assigned to two categories. The first kind of acoustic cue has a linguistic value and is useful, for example, in distinguishing [illegible] from another, or a vowel from a consonant [illegible] those elements which are not linguistically pertinent, but serve only in distinguishing one voice timbre from [illegible] discuss only the first type here.

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By the twofold [illegible] electronic analysis and synthesis, it has been possible to isolate most acoustic cues of speech and to discover optimum physical dimensions by varying a single cue in the synthesis, while keeping the others fixed, and then submitting the variations to psychological tests of auditory perception. It has even been possible to establish a hierarchy of cues based on the role that each cue plays in identifying phonemes. In short, thanks to electronic manipulation of artificial speech, also called synthetic speech, linguists today are familiar with the acoustics of the majority of European languages, and are presently studying the acoustics of African and Asian languages. (The term "acoustics" is understood here in its objective sense of "physics of sound.")

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By the twofold technique of electronic analysis and synthesis, it has been possible to isolate most acoustic cues of speech and to discover optimum physical dimensions by varying a single cue in the synthesis, while keeping the others fixed, and then submitting the variations to psychological tests of auditory perception. It has even been possible to establish a hierarchy of cues based on the role that each cue plays in identifying phonemes. In short, thanks to electronic manipulation of artificial speech, also called synthetic speech, linguists today are familiar with the acoustics of the majority of European languages, and are presently studying the acoustics of African and Asian languages. (The term "acoustics" is understood here in its objective sense of "physics of sound.")

Our purpose here is to describe the acoustic phenomena which might be of interest to the French writer, and in particular to the poet. Naturally, these acoustic phenomena correspond to the articulatory movements which produce them, and which are perhaps not insignificant from the point of view of linguistic perception as well as from that of aesthetic perception. There is, in fact, a school of psychologists who believe that waves of phonemes do not pass directly from the ear to the brain, but rather reach the brain indirectly, after reference to a learned articulatory habit. It is also quite possible that our aesthetic appreciation of consonants, and even of groups of consonants, depends upon articulatory movement, the length of this movement, its complexity, and the degree of difficulty it presents, all of which are characteristics that would be noticed not only in articulating but also in listening. It seems to us, however, that it is the physical vibrating wave of the sound, and not the articulation which produces it, which is of greatest interest to the writer. The acoustic pattern of words is that which corresponds most clearly with the subjective impression that the poet feels and uses to reinforce the expression of his feelings.

Before entering the world of acoustics, let us straightway come to agreement on the terminology to be used. Misunderstandings often arise from a confusion between subjective and objective terms.

The three physical elements of speech are frequency, intensity, and duration. Wave frequency is objectively measurable in "numbers of vibrations per second," and it is perceived subjectively by its "pitch" -- we consider a note to be high because its frequency is high. Wave intensity is measurable in decibels by its amplitude. Its force, however, cannot be measured, but is judged subjectively -- we think that a speech segment is loud because its wave amplitude, or the sum of the wave amplitudes which compose it, is great. Vowel duration is measured in centiseconds (cs), but its length is evaluated by subjective comparison with the length of other vowels.

Let us also agree on the levels of linguistic analysis with which we will concern ourselves here. It will be helpful to distinguish three of them.

The first level is the realm of the phoneme, which is, for the poet, the smallest word segment capable of producing a distinction in meaning by substitution, without having meaning in itself. A Frenchman can understand that _t_, _d_, _n_ are phonemes, distinctive units of his language, because these sounds make it possible to distinguish one word from another: by substituting _d_ for _t_, _bateau_ becomes _badaud_; by substituting _n_ for _d_, _badaud_ becomes _banaux_; by substituting _r_ for _t_, _bateau_ becomes _barreau_, and so on.

At the second level, the term "distinctive feature" is used to designate any general acoustic characteristic which, by itself (or almost), makes it possible to distinguish at least one phoneme from another. _Badaud_ is separated from _bateau_ by a single distinctive features, which is (arbitrarily) called voicing, and from _banaux_ by another distinctive feature called nasality. The phoneme _d_, therefore, possesses at least two distinctive features, one which distinguishes it from _t_, another which distinguishes it from _n_. Actually it has others: one which distinguishes it from _z_, and one which distinguishes it from _b_; and it is distinguished from _r_ by three features. This means that there are four distinctive features separating _bateau_ from _barreau_ even though there is opposition of only one phoneme.

At the third level, the physical factors which go together to make up distinctive features are called "acoustic cues." "Cues," therefore, are even more numerous than "features." Take the feature that we have called voicing, which makes it possible to oppose, for example, pas to bas, cassé to casé. We have been able, by means of physical synthesis, to isolate as many as six different cues -- some frequency factors, some factors of duration or intensity -- for this feature alone. Since there is no longer anything arbitrary about these acoustic cues -- they are physical occurrences, directly observed and measured by means of instruments -- they can be linked directly with phonemes, with syllables, with words, with sentences, without even taking distinctive features into consideration. It is therefore the objective knowledge of acoustic cues, as well as the less objective knowledge of distinctive features, that would interest the poet. How a language sounds aesthetically can in large measure be explained by physical analysis of the unities of language at the different levels.

Let us take as a starting point the difference between consonants and vowels. Recent psycho-acoustic experiments proved that the essential difference lies in the opposition: change versus stability, or from the articulatory point of view: movement versus immobility. All consonants are perceived, wholly or partially, by changes in the musical progression of speech. Vowels are perceived, on the other hand, by stable portions, short as they may be. The faster the tempo (rate) of change, the more consonantal the segment; slow tempos are therefore perceived as semi-consonants or portions of diphthongs. This does not mean that the consonant has no stable portion at all -- in fact, the portion which corresponds to the most closed articulatory position (called hold) is often quite stable -- but the importance of this portion in the perception of a consonant is limited. The classic definition, proposing that a consonant is above all a noise made up of non-periodic vibrations, with or without periodic vibrations as well, is obsolete. It described only the closed portion of the consonant. Actually, the consonant is perceived by the opening or closing movement, more than by the instant of articulatory immobility when the organs are tensed. The dynamic element which makes the consonant perceptible is of vocalic composition and had always been considered as belonging to the vowel. So let us go ahead and see just what vowels are from a physical point of view, and afterwards we shall come back to consonants.

It could be said that a vowel is a chord made up of harmonics. In a general way, this would be true, but it would apply only to non-whispered vowels. Now whispered vowels are just as intelligible as other vowels and have no harmonics (periodic waves) at all -- they have only narrow bands of noise (non-periodic waves). Therefore it is more correct to say that a vowel is a chord of frequency bands, each composed either of noise or of harmonics, depending on whether the vowel is in whispered or non-whispered speech. These bands reflect the notes of resonance of the buccal cavities. And, just as the buccal cavities undergo continual changes in form and volume because of almost unceasing movements of the tongue and other articulatory organs, so also the frequency bands, as revealed by spectral analysis of speech, undergo almost continual changes in frequency and are represented on a spectrogram as wavy lines going from left to right. On this spectrographic representation, vowels are seen as instants of complete or relative stability of the frequencies. Of the numerous bands (five to ten) that show up on a speech spectrum, the two lowest are generally sufficient to identify a vowel; the higher bands are useful in recognizing the voice of the speaker. Consonants are identified usually by the first three bands; therefore, the third band is more important for consonants than for vowels.

There are some simple tricks which make it possible for anyone to perceive, in a general way, the two separate bands which characterize vowel color. The note of the second band of the vowels of *lit*, *lut*, *loue* can be heard by saying *i* [i], *u* [y], *ou* [u] in a forceful whisper. The tones of these three vowels are at frequencies of about 2500, 1800 and 700 cps (cycles per second). The second tone, at 1800 cps, can be whistled, producing a note close to the sound of *la* two octaves higher than *la* at 440 cps. To hear the note of the first band, you tap your throat near the Adam's apple with flicks of the finger, keeping the glottis closed so that the pharyngeal cavity, which is the one you are making resonate, is closed by the vocal cords at its lower limit (if the vocal cords were open it would make this cavity too large by adding to its own volume that of the trachea). Then the vowels you hear are those of *tard*, *tort*, *terre*, which are the easiest to hear, since the first bands in the resonance of the vowels of *lit*, *lut*, *loue* are too low to be heard easily.

We often hear the terms grave and acute in talking about vowels. This notion is based solely on the frequency of the second band, and is justified in the case of vowels at the extremes of the acoustic range, such as *i* and *ou*, whose second bands are at 2500 and 700 cps respectively. But we must remember that vowels are not perceived by a single band, but by a harmony between two bands, in which the first band is just as important as the second. This means that, objectively, *i* can be said to be more acute than *ou* since the first bands of these two vowels are on the same frequency, and the vowels differ only in the second band. In the same way, *é* is objectively more acute than *o*; however, we are perhaps no longer justified in giving *é* the distinction of acute if we compare *i* (low note plus high note) to *é* (note less low plus note less high) of *é* to *a* (two medium notes). But let the poet judge for himself, by examining the approximate frequencies of the first and second bands as they appear in vowels spoken by a Frenchman:

Sire	250 - 2500	
Sûr	250 - 1800	Closed
Sourd	250 - 1700	
Ses	350 - 2100	
Ceux	350 - 1600	Semi-Closed
Sot	350 - 800	
Serre	500 - 1800	
Soeur	500 - 1400	Semi-Open
Sort	500 - 900	
Patte	750 - 1300	
Pâte	750 - 1100	Open

We can see in the above figures that the farther apart the jaws (or the lower the tongue), the higher the first band; and the more rounded the lips and the more backed the tongue, the lower the second band. These three articulatory factors work together to accord a certain volume and closure to each of the two principal buccal cavities. For example with i, since the tongue is high in front and the lips are apart, the back cavity is large with a small opening (very low note) and the front cavity is small with a large opening (very high note). For ou, since the tongue is very high and backed and the lips are rounded, the two cavities are large with small openings and both have low notes. Thus the function of mouth opening and tongue fronting, which figures in traditional notions, is only an indirect one; the notes produced by the cavities and which characterize vowels are directly determined by the size and degree of closure of these cavities. If the note of the first band is highest for the a, it is not because the jaws are open and the tongue is in the center, but because the tongue constriction takes place midway in the pharynx, making the back cavity of the a smaller than that of of any other vowel.

You often hear people speak also of the musical qualities of vowels. Although these qualities unquestionably exist, the term "musical" is perhaps a poor choice, because vowels are perceived on a subjective scale which is not the same as the traditional scale of instrumental music. Vowels, analyzed objectively as musical chords, are nothing more than harsh discords. To prove this for yourself, all you have to do is listen to the two vowel bands separately in the laboratory (by a process of filtering, or by synthesis): the harmonics which form the second band of an *a*, for example, are separated by intervals of a little less than one tone, those of the second band of an *é* are separated by intervals of about a half-tone. Musically speaking, three or four contiguous half-tones form a chord which is dissonant and disagreeable to the ear; the effect of combining several bands of discords as shrill as these should be to accentuate even further the impression of dissonance. Actually this is not at all the case. In the linguistic perception of a vowel, all impressions of musical dissonance disappear and are supplanted by a sound image which is not in any way unpleasant.

Up to this point we have spoken only of the factor of frequency. It is surely the most important factor and usually the only essential one for oral vowels. With nasal vowels, however, intensity also plays an important role. The impression of nasality is produced by a lack of balance between the relative intensities of the first two bands. In experiments with artificial speech synthesis, *sec* can be changed into *cinq*, *pâte* into *pente*, *mode* into *monde* by reducing the intensity of the first band by 10 to 15 decibels, without changing the intensity of the second band. Physiologically, this lessening of intensity occurs when, with the soft palate lowered, the pharyngeal cavity on which the resonance of the first band is dependent assumes the same dimension as that of the small nasal cavity which is just above the soft palate -- this being the only nasal cavity which has linings smooth enough to enable it to resonate. When the volumes of the two cavities are the same, the nasal cavity produces the same harmonics as the pharyngeal cavity, but in inverse phase, which cancels them out. So in nasal vowel perception, the high band dominates, giving an impression of highness; in addition, one of the two elements of the chord is missing or nearly missing, giving an indefinite, hazy, obscure sound in comparison with oral vowels, which are said to be clear and bright.

We have seen that consonants are perceived essentially by rapid frequency changes in the resonance bands. These frequency changes are known as "transitions." Consonants are distinguished from one another by the direction taken by the second and third transitions and by the tempo of their frequency changes. The direction of transitions is what makes it possible to know the place of articulation (labial, dental, alveolar, palatal, etc.), the tempo, and the manner of articulation (stops, fricatives, liquids, semi-vowels, etc.). For labial consonants, the transitions of the second and third bands aim toward low notes; for dentals, the second band transitions turn toward middle notes and those of the third band toward high notes; for post-dental consonants (alveolar, palatal, velar) the second band transitions aim toward high notes and those of the third band toward low notes. These complex combinations of the directions taken by transitions reflect the changes in volume and in shape of the two or three principal buccal cavities. Although each place of articulation depends on a combination of two band movements, it can be said that transitions of labial consonants are associated with low notes, those of dentals with high notes, and those of palatals with middle notes.

The tempo of frequency changes, or rate of transition, in the bands is what separates consonants into classes, or according to "manners of articulation." Stop consonants (plosives as in *pas*, *bas*, or nasals as in *ma*) have the most rapid transitions; the transitions of fricatives (as in *fa*, *va*) are less rapid; and those of liquids and semi-consonants (as in *laid*, *raie*, *hier*, *ouest*) even less rapid. The role of the tempo of transitions can be demonstrated in synthesis: by gradually slowing down labial transitions, the syllable *pi* becomes *bi*, then *vi*, then *oui* and finally *ou-ie*.

Thus the direction and tempo of transitions make it possible to know the place and manner of articulation. In this, however, they are somewhat aided by consonant noises -- explosions like those in *pas*, *tas*, *cas*, *bas*, *dos*, *gai*, or friction noises as in *fais*, *sais*, *chez*, *vais*, *zèle*, *geai*. Note that we say only "somewhat" aided, because their role is very restricted: at a distance of only a few meters, these noises are no longer heard, whereas the range of harmonics of transition bands is as great as that of vowels. However, we must keep in mind that some noises are more effective than others: the friction noises of *chez* and *sais* carry better than those of *geai*, *zèle*, *fais* and *vais*; and the explosion of *cas* carries better than those of *gars*, *pas*, *bas*, *tas*, *dos*.

Burst noises are distinguished from friction noises not by the nature of the noise, but by its duration and by the interruption which precedes it. This is proved by a laboratory experiment. If we distort a recording of the word *assez* by erasing nine-tenths of the friction noise of the *s* sound, we get *athée*, since the transitions of *s* and *t*, whose places of articulation are very close to each other, are almost the same. Inversely if we introduce a silence in the word *sable*, between the friction noise of the *s* and the band transitions which go toward *a*, we get *stable*.

Frequency is the principal factor in distinguishing friction noises from each other, but their intensity and their band width also play a part. *Ch*, *j*, and *s*, *z* all have medium band widths (for consonant noises) and strong intensities; thus they are distinguished from each other mainly by their frequencies, which range from about 2000 to 5000 for *ch* and *j*, and from 3500 to 7000 for *s* and *z*. The frictions of *f* and *v* have a very wide range -- from 1000 to 10,000 -- and are very weak. In these three pairs, of course, the voiced consonants *j*, *z*, *v* have a shorter and less intense noise than the corresponding unvoiced consonants *ch*, *s*, *f*.

Burst noises are distinguished from each other in the same way as friction noises. The burst noises of dentals as in *tard*, *dard*, are the highest, the weakest, and of medium width; those of labials as in *part*, *barre*, are the lowest, the widest, and of average intensity; those of palato-velars as in *car*, *gare*, are the most intense, the narrowest, and of medium pitch (they have about the same pitch as the second formant, and follow its frequency changes).

This takes care of the principal role of noises and of second and third formant transitions. First formant transitions also play their part, both for the manners and for the places of articulation. Let us take two of these cases. Consonants called closed consonants, as in *bas*, *dos*, *vos*, *zoo* are distinguished from consonants called open consonants, as in *la*, *rat*, *hier*, *ouest*, by the tempo of the first transition, which is much slower in the second case -- *vit* can be changed to *oui* simply by slowing down the tempo on the speech synthesizers. And among the open consonants, the pharyngeal *r* in *reste* is in opposition to the buccal consonants of *ouest*, *leste*, *hier* by the direction of the first transition, which points upwards for *r* and down for the others.

We still have two other manners of articulation to examine which have not been covered in speaking of noises and transitions: these are voicing and consonant nasality.

Consonants of the type of *b* or *z* are called voiced, and those like *p* or *s* unvoiced. It was generally believed that this distinction was based entirely on the vibration of the vocal cords (for *b*, *z*) or the absence of vibration (for *p*, *s*). Recent psycho-acoustic research has made it possible to isolate several other factors. Thus *casé* is distinguished from *cassé* not only by the presence of a fundamental wave during the friction, but also by a much shorter duration of the buccal closure, a much weaker intensity of the friction noise, and by the fact that a neutral vowel is resonated along with and throughout the vibration of the friction noise.

As for nasal consonants, their places of articulation depend upon the same rapid transitions as the corresponding stop consonants -- *mot* has the same transitions as *beau*, *nos* the same as *dos* -- but the hold is different. For example, the nasals *m*, *n*, are distinguished from the orals *b*, *d* by a very low fixed tone, at about 250 cycles, during the buccal stop. In synthesis the addition of this tone is enough to change *bas* to *mas*, *dos* to *nos*.

Finally the "duration" factor also plays a part, of course, but it is infinitely less complicated than the factors of intensity and frequency that we have just reviewed.

A longer duration has a "distinctive" effect in French only in the case of three series which are thought of as exceptions: one series in è: *mètre* or *mettre* with a short vowel can be opposed to *maître* with a long vowel; another series in *a*: *tache* with a short vowel can be opposed to *tâche* with a long vowel; and a series in *r*: *courais* with a short consonant can be opposed to *courrais* with a long consonant (which is also true for *mourais* and *mourrais*, *acquérais* and *acquerrais*). In all other cases where differences in duration are found, the difference is not distinctive, and has no linguistic importance.

On the other hand, it can have a good deal of expressive value which poets recognize. It was probably not by chance that Baudelaire chose all the rhymes in _Harmonie du Soir_ in _oir_ and _ige_, since _r_ and _g_ are weak consonants which notably lengthen the preceding vowel. This creates syllable endings which are at the same time both soft and long, thus enhancing the feeling for nature that the poet is trying to express. The objective rules which govern non-distinctive or conditioned duration have been the subject of extensive research. First law: the stronger the consonant, the shorter the preceding vowel, and vice versa. Therefore it is useful for a poet to know the force of articulation of consonants as it has been established instrumentally by phoneticians. The strongest consonants are _p_, _t_, and _c_, and the weakest are _r_, _z_, _j_, and _v_. The others come in between. Thus the vowels in _tape_, _vite_, or _sec_ are a third as long as those in _rêve_, _tige_, _rase_, _sort_. Most other simple consonants fall between these two extremes, but the same is not true for some groups of consonants, which can have an even greater shortening influence than _p_, _t_, _c_: the vowels of _secte_, _certes_, _carpe_, _parc_ are a fourth as long as those of _soir_, _tige_. Second law: all semi-closed or nasal vowels are long when they occur in closed syllables at the end of a word. This is how French can offer differences of duration of the type: _pomme/paume_, _jeune/jeûne_, _bas/banque_, _sept/sainte_, which are not "distinctive" because they are found only in "complimentary distribution."

With consonants, as we have seen, duration comes into play frequently on the acoustic level. The duration of the noise is what distinguishes _ta_ from _sa_, as well as the presence or absence of an interruption. And the duration of the constriction contributes a good deal in distinguishing _rateau_ (long interruption) from _radeau_ (short interruption), _cassé_ (long noise) from _casé_ (short noise).

Let us repeat that all these differences in duration, great as they may be, are always made unconsciously because they are conditioned -- which makes their value to the poet all the greater.

One of the dimensions which the writer could make use of is found in the quantity of noise, that is, non-periodic harmonic sound, which causes a consonant to be heard during its hold (term referring to the most closed phase of articulation, directly preceding the transitions of the harmonic bands). The friction noises in fou, sous, chou are the most pronounced, the least harmonic. The burst noises of pou, tout, coup are not far behind -- their noise is very short, but its subjective effect is intensified by the duration of the interruption which precedes it. Next the voiced frictions of vêle, zêle, gel contain a little friction noise during the buccal constriction, but this friction noise is drowned out by a complex harmonic sound made up of several vowel bands of very low intensity. In the voiced plosives of bout, doux, goût there is, in the same way, a burst of noise just when the organs separate, but it is barely audible because it is drowned out by the vibration of several low-pitched harmonics. In the hold of nasal consonants such as in mon, non, gnon, there is no longer any noise at all -- only harmonics (unless one is whispering) grouped on several bands, only the lowest of which has a fair amount of intensity. The hold of the "liquids" in long and rond is equally void of noise. This hold is composed of harmonic bands which are more intense than those of nasals, but less intense than those of true vowels. It is essentially by the frequency of the first band that the hold of liquids differs from that of nasals -- the frequency is very low for nasals, less low for l and relatively high for r. Of all the consonants, the liquids are the ones that have the most resonant hold, if we understand resonance to mean the absence of noise to the utmost, and relatively great intensity as compared to other consonant holds.

This also explains why poets prefer liquid consonants in passages where they are seeking the vocalic qualities of consonants.

Finally, semi-consonants or semi-vowels as in hier, oui, huit do not have any hold to speak of -- they are perceived almost uniquely by slow transitions of resonance bands. They differ slightly from each other in the degree of closure at the beginning, which is more obvious in hier than in oui or huit. This means that after an unvoiced consonant, the semi-vowel in pied can produce more friction than those of pois and puis. In these examples, what actually happens is that a devoicing of the semi-vowel takes place, under the influence of the strong consonant which precedes it. This type of devoicing by assimilation applies equally to liquid consonants as in long and rond. The hold of l or r devoices to a great extent when it comes into contact with unvoiced consonants, as in pli, pris. In final position, as in ample, âpre, they can even devoice completely.

The poet should not fail to take this type of consonantal assimilation into consideration. A consonant such as one which is soft and resonant by nature can become as hard and surd as a true unvoiced fricative, under the influence of phonetic environment. The consonant r which, after a final vowel as in fleur, fades into soft harmonics, comes back strong as a dull, rough noise when it follows an unvoiced occlusive as in cri. If by chance the meaning has a relation to the sound, as is the case here, the poet will not fail to make use of it.

A last look at distinctive features will lead us to another notion which can be used for aesthetic effect: the degree of differentiation. Two French consonants can be differentiated from each other by one, two, three or four distinctive features, or even more, according to theories that are generally accepted.

For the linguist, the greater the number of features which separate two phonemes, the less chance there is for confusion. For example, if ami and habit, which are distinguished from each other by only one feature -- the resonance of the nasal tone during the hold -- were mingled in the hum of a conversation, a subway din or an engine roar, they would be more likely to be confused than ami and assis, which are distinguished from each other by at least three features: nasal resonance as opposed to oral resonance during the hold, periodic vibration of nasal harmonics as opposed to non-periodic vibration of the friction noise (also during the hold) and the transition bands of labials as opposed to those of dentals (after the hold, during the opening movement). From this controlled play of the degrees of distinction or confusion between two sounds or classes of sounds, and especially that of types of distinction, the poet should be able to derive a great wealth of effects. The predominance in a line of poetry of very distinct consonants, that is, consonants differentiated by several features, should lend itself to associations that are clearer, more pronounced, more violent and more vigorous than those of consonants having the same manner or place of articulation. The sequence sapanayaka is far richer and more varied in resonance than pabamavawa, in which all the consonants have the same place of articulation, or vazajalara, in which their manner of articulation is the same.

Let us mention by name the features which are most useful for French. These are on the one hand the PLACE of articulation, which distinguishes, for example, fa from sa; and on the other hand the tempo of articulation, which distinguishes vit from oui; discontinuity, which distinguishes ta from sa; nasality, which distinguishes nez from dé; and voicing which distinguishes casé from cassé. These last four features are features of

MANNER of articulation. They are designated here by conventional articulatory terms, but remember that our classifications are based on acoustic experiments, not on articulation itself, and that each feature is related to a combination of several acoustic cues. Moreover, each major feature involves minor features that are conditioned by it.

Pairs of French consonants whose contrasting phonemes are distinguished by four features will be shown here as they appear in oppositions of words.

Distinctive features of discontinuity, tempo, voicing and place of articulation: père/hier, pile/huile, test/ouest, terre/hier, qui/oui, quitte/huit, pas/las, cas/las, tas/rat, cas/rat.

Distinctive features of discontinuity, voicing, nasality, point of articulation: mot/sot, mot/chaud, nos/faux, nos/chaud, gagné/gaffé, baigné/baissé.

Distinctive features of discontinuity, tempo, nasality, point of articulation: ému/élu, donné/doré, signé/ciré, signe/cil, ni/oui, nerf/hier, mi-jour/huit jours, mer/hier, rimant/riant.

Distinctions in which three features differ still have a high degree of differentiation.

Distinctive features of voicing, nasality, place of articulation: pont/non, pont/gnon, gâta/gamma, gâta/gagna, cou/mou, cou/nous.

Distinctive features of voicing, discontinuity, place of articulation: coupez/cousez, happé/âgé, anti/envie, hâté/âgé, cou/vous, rauque/rose, habit/assis, beau/chaud, dos/faux, doux/choux, goût/sous.

Distinctive features of tempo, discontinuity, place of articulation: boue/loue, doux/roux, gai/laid, gui/riz, binaire/huit nerfs, à beurre/ailleurs, d'Est/Ouest, aidant/ayant, gâte/ouate, guidant/huit dents.

Distinctive features of nasality, discontinuity, place of articulation: *aimé/aisé*, *ramer/rager*, *anis/avis*, *année/âgé*, *gagner/gaver*, *signeaux/ciseaux*.

Distinctive features of voicing, tempo, place of articulation: *fa/la*, *son/rond*, *chou/roue*, *chat/là*, *fissiez/huissier*, *fer/hier*, *si/oui*, *sert/hier*, *chatte/ouate*, *chignon/huit gnons*.

No less useful to the poet is a knowledge of the different types of consonant SIMILARITIES. Distinctions by a single feature are shown below in oppositions of words.

In each of the following series, the distinction is due primarily to the place of articulation: *pèle*, *tel*, *quel*. *Bout*, *doux*, *goût*. *Hameau*, *anneau*, *agneau*. *Café*, *cassé*, *caché*. *Avis*, *asie*, *agit*. *Mouette*, *muette*, *miette*. *Grève*, *glève*.

All the following initial consonants have in common a second band transition which turns downward: *pas*, *bas*, *ma*, *fa*, *va*, *oie*, *rat*. (If *r*, which is pharyngeal, is classed here acoustically with the labials, it is because the buccal cavity is large in the two cases -- for the labials, it is large behind the lip constriction, and for the pharyngeals, it is large in front of the pharyngeal constriction.)

All the following consonants have in common a second band transition aiming toward a note of medium frequency: *tes*, *des*, *nez*, *ses*, *zé*, *les*, *huées*.

All the following initial consonants aim toward a note of high frequency by their second transition: *Caire*, *guerre*, *chère*, *Gers*, *hier*.

In the following pairs the distinction depends mainly on a single feature:

Voiced/unvoiced: *Beau/pot*, *doux/toux*, *grès/craie*, *vive/vif*, *Asie/assis*, *joue/chou*.

Oral/nasal: Beau/mot, doux/nous, gond/gnon (this last consonant actually has its point of stricture more forward than g, but the two consonants have the same type of second band transitions).

Continued/discontinued: Faux/pot, ses/tes, chou/cou, vont/bon, zoo/dos, joue/goût.

Fast tempo/slow tempo: Va/oie.

In closing, let us say a few words about syllables. The syllable is a rhythmic unit composed of sounds which a re compactly linked together. There is a division of syllables wherever two successive phonemes are not compactly linked together. Syllables can also be defined according to the rate of change in frequency of the bands, which normally decreases up until the vowel, and increases afterward; the vowel, in the middle of the syllable, provides an instant of stability in the frequency of the bands. A syllable, therefore, is composed either of a decreasing frequency change (type ba) or of an increasing change (type ab), or of a change which decreases and then increases (type bab), which can reach a high degree of complexity: tsyarsp.

The fact that there is of necessity one vowel, and no more than one vowel, per syllable allows us to oppose a vowel to a consonant by describing them respectively as the central part or the marginal part of the syllable. The number of consonants per syllable can therefore vary a good deal. A syllable seems heavy or light depending on the number of consonants that surround the vowel..

By controlling these factors, the poet can produce effects of slowness, gravity, weight, volume, majesty, wisdom, etc., or their opposites. Syllables loaded with consonants, as in quartz, marbre, svelte, spectre, lorsque, cannot be articulated at the same rhythm and with the same lightness as si, mi, la, ré, do. One can see that adding just one consonant to each syllable makes an utterance considerably heavier. Compare, for example, two sentences such as: De longs jets d'eau les arrosaient, and Quelles belles feuilles rouges cachent cette longuepente.

Let us summarize. Non-whispered speech is music of a particular kind. It is perceived almost entirely by three narrow bands of harmonic sound whose frequencies fluctuate from 300 to 3000 vibrations per second, and which reflect the continual changes in form and volume of the buccal cavities. The noises of friction and explosion which are associated with consonants actually play only a very unobtrusive role. Noises do not carry. As the bands of harmonic sound move along, their abrupt rises and falls cause consonant sounds to be heard, and their slowing down causes vowel sounds to be heard. Consonants are distinguished from one another by the direction of the melodic movements of the bands and the tempo of these movements; while vowels are distinguished from one another by the frequency of their first two bands; and nasal vowels are distinguished from oral vowels by the weakness of the low notes, which brings about a lack of balance in the relative intensities of the two bands. This imbalance is what is subjectively called "nasality." In these modulations of frequency, of intensity, and of tempo, the French language offers the poet a wide range of exceptionally rich and varied possibilities of expression.

LANGUAGE LEARNING AND LINGUISTIC INTERFERENCE

Among the many definitions of the term "language," the one that applies best to teaching languages is perhaps: a set of linguistic habits. In learning a second language one must acquire a new set of linguistic habits. We are used to thinking first of all of articulatory habits, but there are others of equal importance, such as grammatical habits -- often separated into morphologic habits and syntactic habits -- semantic habits, orthographic habits, phonemic habits, phonetic habits, prosodic habits, and so on. There are also habits of a purely psychological nature, such as the habit of sound-sense association -- the ability to speak a language fluently seems to depend on one's ability to associate meaning directly with sound and not with any visual symbolization of sound such as spelling.

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The sort of interference we are concerned with here comes from such habits. When learning a second language, all the linguistic habits of an adult's first (native) language interfere; they stand in the way of the new habits that must be acquired. The advantage a child has over an adult is, of course, due to his having not yet acquired deeply rooted language habits. Successful language teaching depends, therefore, on the instructor being aware of the interferences the students are subjected to by their native habits. The purpose of this paper is to increase and clarify this awareness.

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To every kind of habit there corresponds a kind of interference. We can speak, therefore, of syntactic interference, morphologic interference, semantic interference, orthographic interference, phonemic interference, phonetic interference, and so on. Let us take concrete examples.

Syntactic interference is related to word order and the arrangement of semantic units in a sentence. When an American student of Spanish, who wants to indicate that he has been here for three days says *He estado aquí por tres días*, instead of *Hace tres días que estoy aquí*, it is because of syntactic interference; he transfers to Spanish the syntactic form and word order of his native English. Under the same influence, a student of German might say *Ich bin gewesen hier für drei Tage*, instead of *Ich bin seit drei Tagen hier*; and a student of of French, *J'ai été mangé pour deux heures*, instead of *Je mange depuis deux heures* or *J'en ai trop beaucoup* for *J'en ai beaucoup trop*. One of the most hilarious lines in *L'anglais tel qu'on le parle* is *Voici le gris chapeau de mon père*, spoken by Betty, a young English girl. The fact that the simple displacement of the adjective of color, *gris*, to the slot it would occupy in English -- before the noun cannot pass unnoticed, gives ample proof of the importance of syntactic interferen

Morphologic interference is related to roots, endings, particles, affixes, or any other minimal unit of speech which carries grammatical or referential meaning. The student of French who says: *Je suis content qu'il viendra* for *Je suis content qu'il vienne*, or *Attendez pour moi* instead of *Attemdez-moi*, is a victim of morphologic interference. So is the student of Spanish who says *Espera para mí* for *Espérame*, or the student of German who says *Warte für mich* instead of *Warte auf mic*

Semantic interference occurs mostly through literal translations which do not find a correspondence with the same meaning in the second language. A dictionary of such confusions is entitled "Les faux amis." The student of German who said *Was für ein schöner Mist* did not mean to use the word for "manure" but to remark poetically about the mist over the valley. After a good long meal at the French House, an American student will often be heard to say *Je suis pleine* for *Je suis rassasiée* or, if the room is cold, *Je suis froide* for *J'ai froid*. And a student of Spanish who means to apologize will say *Estoy embarazada*, which refers to the same notion as *Je suis pleine*!

Interference is said to be phonemic when one phoneme is pronounced so much like another one of the same language that the meaning which is understood by a native of the second language is not the one desired by the learner of that second language. Thus, the confusion between [u] and [y] often occurs. English articulatory habits are such that if the lips are rounded, the tongue wants to be backed. For this reason, an English student of French who wants to ask *You are sure?* will say *Vous êtes sourd?* (You are deaf?) instead of *Vous êtes sûr?* Once a speaker of Southern German exclaimed in French *Il pleut des chats!* (It is raining cats! when he meant *Il pleut déjà* (It is raining already).)

Orthographic interference is related to the reflex one has at the sight of a printed symbol. Upon seeing the letter *r*, an American student feels his tongue irresistibly pulling back-and-up towards the palate to produce the r-color which is so characteristic of Mid-Western American English, and the foreign sound he is trying to produce suffers sadly, whether it be the German pharyngeal glide which requires lowering the tongue tip, or the Spanish alveolar flap which requires fronting of the whole tongue. Similarly, at the sight of an *n* or *m* letter, the velum (soft palate) of an American falls a good half-syllable ahead of schedule, and the vowel in course acquires a marked nasal quality which changes Jeanne into [ʒãn].

Finally, phonetic interference is what prevents a student from speaking a second language with a good accent even though he uses all the correct phonemes. Unlike phonemic interference, it does not change the meaning, but it can make whole sentences unintelligible. This fact is well illustrated in the story of the American diplomat who was telling a French lady sitting next to him at a banquet how intensively he had traveled: J'ai été un ãn à Rome, un ãn à Genève, un ãn à Madrid, et un ãn à Berlin." The French lady became so irritated by his poor pronunciation of the word an, which should have been [ã], and not [ãn], that she interrupted him to say: "En somme, vous avez été un âne partout (so you have been an ass everywhere)." Note that she had understood his utterance perfectly well. She only pretended that she had not in order to ridicule his poor accent. That is why this interference must be called phonetic, not phonemic.

Phonetic interference involves all sorts of articulatory or prosodic features: nasalization (as in this story), diphthongization, palatalization, aspiration, anticipation, affrication, vowel reduction, retroflexion, fronting, backing, lengthening, shortening, laxness, tenseness, intonation, stress, rhythm, juncture, syllabication, and so on. In our research laboratory, we use electronic devices to analyze all those features and many more. We can isolate, by means of spectrographic devices, as many as forty phonetic differences between English and Spanish, English and German, or English and French. We even synthesize those differences on artificial-speech machines. But rather than listing forty differences now, let us examine one in detail, that of diphthongization. A moving picture will furnish a concrete illustration.

To help language teachers realize the diphthongal habits of their American students, we made a film comparing the lips of American, French, German and Spanish subjects articulating the vowels /e, o, i, u/ in phonetically similar sentences. Vowels to be compared are in similar stress position and are preceded by the same class of consonants. Here is a list of the sentences pronounced in the film.

English vs French

The day before pay wasn't gay.
Céder à l'épée n'est pas gai.

They can tow where they go for the bow.
Ces bateaux sont égaux et sont beaux.

McKee has a bee in his tea.
Chez qui sont partis ses habits?

It will do to say "boo" when they coo.
M. Ledoux est dans la boue jusqu'au cou.

English vs German

In vain they work every day.
Für wen gibt es keinen Tee?

The boat sailed down the Po.
Das Boot schwimmt auf dem Po.

It's deep to his knee.
Ein Dieb war er nie.

They found at noon the shoe.
Er findet nun den Schuh.

English vs Spanish

It's a day still to face.
Qué le dé dos cafés!

It's low pay to cope with.
Don Lope de la Copa.

At least it's a key.
La lista está aquí.

The soup is for two.
Lo supe cuando tú.

The term diphthongization is used to indicate that the color of a vowel changes while it is being produced. Since no vowel is absolutely free of change, if would be safe to specify that vowels are said to be diphthongized when the modification of vowel-color is quite noticeable, and they are said to be pure when the modification is not very noticeable. Note that we are not talking about true diphthongs, such as /aj, aw, oj/ in file, foul, foil. The vowels /ej, ow, ij, uw/ of raid, road, reed, rude are only considered "diphthongized vowels." Naturally, changes of vowel color that are noticeable by ear should reflect articulatory motions or changes of position that are noticeable by eye. It is in order to permit one to observe such motion on the lips of American subjects, and lack of such motion on the lips of French, German, or Spanish subjects that our films were made.

Let us now describe what can be observed on the film to explain the interference of diphthongization in American students.

1. The articulatory motion of the American subject is amazingly extensive. In the word tow, for instance, the lips open sharply to a wide [ɔ] position, considerably overshooting the [o] target in the degree of opening, then close very gradually, taking about four times as long for the closing as for the opening, overshooting the [o] target in degree of closure and going all the way to a lip position of [u] or [w]. By contrast, for the vowels of Beaux in French, Boot in German, and Lope in Spanish, the lips move directly to the [o] position with its required opening (small in German and French, less small in Spanish) and remain there without any very noticeable change for several frames.

2. The onset of the vowel is strong and sudden, whereas its ending is weak and gradual. This is shown first in the rapid opening motion of the start and the slow closing motion of the end, secondly in the high amplitude of the sound waves

near the beginning of the diphthong and in their low amplitude near the end of it. The intensity decreases continuously after the high beginning. Most of the energy seems to be spent in the first quarter of the diphthong. At the end, the sound fades out very gradually.

In the other three languages, the onset of the vowel is gradual and somewhat weak, and the initial amplitude is maintained throughout. The rate of energy is about the same at the end as it is at the beginning, and the vowel ends in a sharp reduction of sound which reflects a sudden contraction in the larynx.

3. In our three foreign languages, the lips show a high degree of vowel anticipation while the consonant is being articulated. For instance, the lips of the French subject are in position for /o/ almost during the whole time the tongue tip touches the alveolar ridge for /t/. In English, on the contrary, the lips move toward the /o/ position well after the consonant closure has occurred. We say that vowel anticipation is weak.

4. While the extensive motion of the American subject occurs, remarkable laxness can be observed in facial expression. Laxness is often debated as a factor of diphthongization because of the difficulty encountered in measuring it objectively. But on this film, thanks to the efficiency of motion photography, laxness is so clearly visible around the lips that its existence leaves no doubt whatsoever. By contrast, the facial expression of the French, the German, or the Spanish subjects show a high degree of muscular tenseness.

In conclusion, it can be said that the application of the term "diphthongized" to the American vowels of raid, road, reed, rude, is well founded. In motion pictures of the lips, those vowels show extensive articulatory motion, strong and sudden onset, lack of anticipation, and muscular laxness. The application of the term "pure" to the corresponding vowels of French, German, and Spanish is also surprisingly well justified. These foreign vowels show no noticeable lip motion, a weak and gradual onset, a high degree of anticipation, and striking muscular tenseness in the facial expression around the lips. When learning French, German, or Spanish, therefore, an American meets, in his habits of vowel diphthongization, the obstacle of phonetic interference. An instructor who is aware of this will be able to help the student to overcome this obstacle by teaching him economy of articulatory motion, gradual vowel onset, vowel anticipation, and muscular tenseness.

SUMMARY. The various types of linguistic interference an American student is subjected to when learning French, German, or Spanish, are described here by comparing the habits involved in each of those four languages. One example of phonetic interference -- diphthongization -- is analyzed in detail with the help of motion pictures of the lips. Those pictures are taken during the utterance of English, French, German, and Spanish sentences in which corresponding vowels are placed in similar conditions of stress and phonetic environment. They demonstrate convincingly that the terms "diphthongized" for English vowels and "pure" for French, German, and Spanish vowels, are well founded.